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60th Congress } SENATE { Document
2d Session } { No. 676

REPORT OF THE NATIONAL CONSERVATION COMMISSION

FEBRUARY
1909

SPECIAL MESSAGE FROM THE PRESIDENT OF THE UNITED STATES

TRANSMITTING A REPORT OF THE
NATIONAL CONSERVATION COMMISSION, WITH ACCOMPANYING PAPERS

IN THREE VOLUMES

VOLUME I

EDITED UNDER THE DIRECTION OF THE EXECUTIVE
COMMITTEE BY HENRY GANNETT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

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SENATE OF THE UNITED STATES,
February 18, 1909.

Resolved, That the special message from the President of the United States, transmitting a report of the National Conservation Commission, with accompanying papers and illustrations, be printed in full as a document, taking number 676 of the present Congress, the number of the document containing the special message of the President transmitting this report.

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SPECIAL MESSAGE OF THE PRESIDENT

TRANSMITTING THE

REPORT OF THE NATIONAL CONSERVATION COMMISSION

To the Senate and House of Representatives:

I transmit herewith a report of the National Conservation Commission, together with the accompanying papers. This report, which is the outgrowth of the conference of governors last May, was unanimously approved by the recent joint conference held in this city between the National Conservation Commission and governors of States, state conservation commissions, and conservation committees of great organizations of citizens. It is therefore in a peculiar sense representative of the whole nation and all its parts.

With the statements and conclusions of this report I heartily concur, and I commend it to the thoughtful consideration both of the Congress and of our people generally. It is one of the most fundamentally important documents ever laid before the American people. It contains the first inventory of its natural resources ever made by any nation. In condensed form it presents a statement of our available capital in material resources, which are the means of progress, and calls attention to the essential conditions upon which the perpetuity, safety, and welfare of this nation now rest and must always continue to rest. It deserves, and should have, the widest possible distribution among the people.

The facts set forth in this report constitute an imperative call to action. The situation they disclose demands that we, neglecting for a time, if need be, smaller and less vital questions, shall concentrate an effective part of our attention upon the great material foundations of national existence, progress, and prosperity.

This first inventory of natural resources prepared by the National Conservation Commission is undoubtedly but the beginning of a series which will be indispensable for dealing intelligently with what we have. It supplies as close an approximation to the actual facts as it was possible to prepare with the knowledge and time available. The progress of our knowledge of this country will continually lead to more accurate information and better use of the sources of national strength. But we can not defer action until complete accuracy in the estimates can be reached, because before that time many of our resources will be practically gone. It is not necessary that this inventory should be exact in every minute detail. It is essential that it should correctly describe the general situation; and that the present inventory does. As it stands it is an irrefutable proof that the conservation of our resources is the fundamental question before this nation, and that our first and greatest task is to set our house in order and begin to live within our means.

The first of all considerations is the permanent welfare of our people; and true moral welfare, the highest form of welfare, can not permanently exist save on a firm and lasting foundation of material well-being. In this respect ~~our~~ situation is far from satisfactory. After every possible allowance has been made, and when every hopeful indication has beeen given its full weight, the facts still give reason for grave concern. It would be unworthy of our history and our intelligence, and disastrous to our future, to shut our eyes to these facts or attempt to laugh them out of court. The people should and will rightly demand that the great fundamental questions shall be given attention by their representatives. I do not advise hasty or ill-considered action on disputed points, but I do urge, where the facts are known, where the public interest is clear, that neither indifference and inertia, nor adverse private interests, shall be allowed to stand in the way of the public good.

The great basic facts are already well known. We know that our population is now adding about one-fifth to its numbers in ten years, and that by the middle of the present century perhaps one hundred and fifty million Americans, and by its end very many millions more, must be fed and clothed from the products of our soil. With the steady growth in population and the still more rapid increase in consumption, our people will hereafter make greater and not less demands per capita upon all the natural resources for their livelihood, comfort, and convenience. It is high time to realize that our responsibility to the coming millions is like that of parents to their children, and that in wasting our resources we are wronging our descendants.

We know now that our rivers can and should be made to serve our people effectively in transportation, but that the vast expenditures for our waterways have not resulted in maintaining, much less in promoting, inland navigation. Therefore, let us take immediate steps to ascertain the reasons and to prepare and adopt a comprehensive plan for inland-waterway navigation that will result in giving the people the benefits for which they have paid but which they have not yet received. We know now that our forests are fast disappearing, that less than one-fifth of them are being conserved, and that no good purpose can be met by failing to provide the relatively small sums needed for the protection, use, and improvement of all forests still owned by the Government, and to enact laws to check the wasteful destruction of the forests in private hands. There are differences of opinion as to many public questions; but the American people stand nearly as a unit for waterway development and for forest protection.

We know now that our mineral resources once exhausted are gone forever, and that the needless waste of them costs us hundreds of human lives and nearly $300,000,000 a year. Therefore, let us undertake without delay the investigations necessary before our people will be in position, through state action or otherwise, to put an end to this huge loss and waste, and conserve both our mineral resources and the lives of the men who take them from the earth.

I desire to make grateful acknowledgment to the men, both in and out of the government service, who have prepared the first inventory of our natural resources. They have made it possible for this nation to take a great step forward. Their work is helping us to see that the greatest questions before us are not partisan questions, but questions upon which men of all parties and all shades of opinion may be united for the common good. Among such questions, on the material side, the conservation of natural resources stands first. It is the bottom round of the ladder on our upward progress toward a condition in which the nation as a whole, and its citizens as individuals, will set national efficiency and the public welfare before personal profit.

The policy of conservation is perhaps the most typical example of the general policies which this Government has made peculiarly its own during the opening years of the present century. The function of our Government is to insure to all its citizens, now and hereafter, their rights to life, liberty, and the pursuit of happiness. If we of this generation destroy the resources from which our children would otherwise derive their livelihood, we reduce the capacity of our land to support a population, and so either degrade the standard of living or deprive the coming generations of their right to life on this continent. If we allow great industrial organizations to exercise unregulated control of the means of production and the necessaries of life, we deprive the Americans of to-day and of the future of industrial liberty, a right no less precious and vital than political freedom. Industrial liberty was a fruit of political liberty, and in turn has become one of its chief supports, and exactly as we stand for political democracy so we must stand for industrial democracy.

The rights to life and liberty are fundamental, and like other fundamental necessities, when once acquired, they are little dwelt upon. The right to the pursuit of happiness is the right whose presence or absence is most likely to be felt in daily life. In whatever it has accomplished, or failed to accomplish, the administration which is just drawing to a close has at least seen clearly the fundamental need of freedom of opportunity for every citizen. We have realized that the right of every man to live his own life, provide for his family, and endeavor, according to his abilities, to secure for himself and for them a fair share of the good things of existence, should be subject to one limitation and to no other. The freedom of the individual should be limited only by the present and future rights, interests, and needs of the other individuals who make up the community. We should do all in our power to develop and protect individual liberty, individual initiative, but subject always to the need of preserving and promoting the general good. When necessary, the private right must yield, under due process of law and with proper compensation, to the welfare of the commonwealth. The man who serves the community greatly should be greatly rewarded by the community; as there is great inequality of service, so there must be great inequality of reward; but no man and no set of men should be allowed to play the game of competition with loaded dice.

All this is simply good common sense. The underlying principle of conservation has been described as the application of common sense to common problems for the common good. If the description is correct, then conservation is the great fundamental basis for national efficiency. In this stage of the world's history, to be fearless, to be just, and to be efficient are the three great requirements of national life. National efficiency is the result of natural resources well handled, of freedom of opportunity for every man, and of the inherent capacity, trained ability, knowledge, and will, collectively and individually, to use that opportunity.

This administration has achieved some things; it has sought, but has not been able, to achieve others; it has doubtless made mistakes; but all it has done or attempted has been in the single, consistent effort to secure and enlarge the rights and opportunities of the men and women of the United States. We are trying to conserve what is good in our social system, and we are striving toward this end when we endeavor to do away with what is bad. Success may be made too hard for some if it is made too easy for others. The rewards of common industry and thrift may be too small if the rewards for other, and on the whole less valuable, qualities, are made too large, and especially if the rewards for qualities which are really, from the public standpoint, undesirable are permitted to become too large. Our aim is so far as possible to provide such conditions that there shall be equality of opportunity where there is equality of energy, fidelity, and intelligence; when there is a reasonable equality of opportunity the distribution of rewards will take care of itself.

The unchecked existence of monopoly is incompatible with equality of opportunity. The reason for the exercise of government control over great monopolies is to equalize opportunity. We are fighting against privilege. It was made unlawful for corporations to contribute money for election expenses in order to abridge the power of special privilege at the polls. Railroad-rate control is an attempt to secure an equality of opportunity for all men affected by rail transportation; and that means all of us. The great anthracite coal strike was settled, and the pressing danger of a coal famine averted, because we recognized that the control of a public necessity involves a duty to the people, and that public intervention in the affairs of a public-service corporation is neither to be resented as usurpation nor permitted as a privilege by the corporations, but on the contrary to be accepted as a duty and exercised as a right by the Government in the interest of all the people. The efficiency of the army and the navy has been increased so that our people may follow in peace the great work of making this country a better place for Americans to live in, and our navy was sent round the world for the same ultimate purpose. All the acts taken by the Government during the last seven years, and all the policies now being pursued by the Government, fit in as parts of a consistent whole.

Our public-land policy has for its aim the use of the public land so that it will promote local development by the settlement of home makers; the policy we champion is to serve all the people legitimately and openly, instead of permitting the lands to be converted, illegitimately and under cover, to the private benefit of a few. Our forest policy was established so that we might use the public forests for the permanent public good, instead of merely for temporary private gain. The reclamation act, under which the desert parts of the public domain are converted to higher uses for the general benefit, was passed so that more Americans might have homes on the land.

These policies were enacted into law and have justified their enactment. Others have failed, so far, to reach the point of action. Among such is the attempt to secure public control of the open range, and thus to convert its benefits to the use of the small man, who is the home maker, instead of allowing it to be controlled by a few great cattle and sheep owners.

The enactment of a pure-food law was a recognition of the fact that the public welfare outweighs the right to private gain, and that no man may poison the people for his private profit. The employers' liability bill recognized the controlling fact that while the employer usually has at stake no more than his profit, the stake of the employee is a living for himself and his family.

We are building the Panama Canal; and this means that we are engaged in the giant engineering feat of all time. We are striving to add in all ways to the habitability and beauty of our country. We are striving to hold in the public hands the remaining supply of unappropriated coal, for the protection and benefit of all the people. We have taken the first steps toward the conservation of our natural resources, and the betterment of country life, and the improvement of our waterways. We stand for the right of every child to a childhood free from grinding toil, and to an education; for the civic responsibility and decency of every citizen; for prudent foresight in public matters, and for fair play in every relation of our national and economic life. In international matters we apply a system of diplomacy which puts the obligations of international morality on a level with those that govern the actions of an honest gentleman in dealing with his fellow-men. Within our own border we stand for truth and honesty in public and in private life, and war sternly against wrongdoers of every grade. All these efforts are integral parts of the same attempt, the attempt to enthrone justice and righteousness, to secure freedom of opportunity to all of our citizens, now and hereafter, and to set the ultimate interest of all of us above the temporary interest of any individual, class, or group.

The nation, its government, and its resources exist, first of all, for the American citizen, whatever his creed, race, or birthplace, whether he be rich or poor, educated or ignorant, provided only that he is a good citizen, recognizing his obligations to the nation for the rights and opportunities which he owes to the nation.

The obligations, and not the rights, of citizenship increase in proportion to the increase of a man's wealth or power. The time is coming when a man will be judged, not by what he has succeeded in getting for himself from the common store, but by how well he has done his duty as a citizen, and by what the ordinary citizen has gained in freedom of opportunity because of his service for the common good. The highest value we know is that of the individual citizen, and the highest justice is to give him fair play in the effort to realize the best there is in him.

The tasks this nation has to do are great tasks. They can only be done at all by our citizens acting together, and they can be done best of all by the direct and simple application of homely common sense.

The application of common sense to common problems for the common good, under the guidance of the principles upon which this republic was based, and by virtue of which it exists, spells perpetuity for the nation, civil and industrial liberty for its citizens, and freedom of opportunity in the pursuit of happiness for the plain American, for whom this nation was founded, by whom it was preserved, and through whom alone it can be perpetuated. Upon this platform—larger than party differences, higher than class prejudice, broader than any question of profit and loss—there is room for every American who realizes that the common good stands first.

The National Conservation Commission wisely confined its report to the statement of facts and principles, leaving the Executive to recommend the specific steps to which these facts and principles inevitably lead. Accordingly, I call your attention to some of the larger features of the situation disclosed by the report, and to the action thereby clearly demanded for the general good.

WATERS.

The report says:

> Within recent months it has been recognized and demanded by the people, through many thousand delegates from all States assembled in convention in different sections of the country, that the waterways should and must be improved promptly and effectively as a means of maintaining national prosperity.
>
> The first requisite for waterway improvement is the control of the waters in such manner as to reduce floods and regulate the regimen of the navigable rivers. The second requisite is development of terminals and connections in such manner as to regulate commerce.

Accordingly, I urge that the broad plan for the development of our waterways recommended by the Inland Waterways Commission be put in effect without delay. It provides for a comprehensive system of waterway improvement extending to all the uses of the waters and benefits to be derived from their control, including navigation, the development of power, the extension of irrigation, the drainage of swamp and overflow lands, the prevention of soil wash, and the purification of streams for water supply. It proposes to carry out the work by coordinating agencies in the federal departments through the medium of an administrative commission or board, acting in cooperation with the States and other organizations and individual citizens.

The work of waterway development should be undertaken without delay. Meritorious projects in known conformity with the general outlines of any comprehensive plan should proceed at once. The cost of the whole work should be met by direct appropriation if possible, but if necessary by the issue of bonds in small denominations.

It is especially important that the development of water power should be guarded with the utmost care both by the National Government and by the States in order to protect the people against the upgrowth of monopoly and to insure to them a fair share in the benefits which will follow the development of this great asset which belongs to the people and should be controlled by them.

FORESTS.

I urge that provision be made for both protection and more rapid development of the national forests. Otherwise, either the increasing use of these forests by the people must be checked or their protection against fire must be dangerously weakened. If we compare the actual fire damage on similar areas on private and national forest lands during the past year, the government fire patrol saved commercial timber worth as much as the total cost of caring for all national forests at the present rate for about ten years.

I especially commend to the Congress the facts presented by the commission as to the relation between forests and stream flow in its bearing upon the importance of the forest lands in national ownership. Without an understanding of this intimate relation the conservation of both these natural resources must largely fail.

The time has fully arrived for recognizing in the law the responsibility to the community, the State, and the nation which rests upon the private owners of private lands. The ownership of forest land is a public trust. The man who would so handle his forest as to cause erosion and to injure stream flow must be not only educated, but he must be controlled.

The report of the National Conservation Commission says:

> Forests in private ownership can not be conserved unless they are protected from fire. We need good fire laws, well enforced. Fire control is impossible without an adequate force of men whose sole duty is fire patrol during the dangerous season.

I hold as first among the tasks before the States and the nation in their respective shares in forest conservation the organization of efficient fire patrols and the enactment of good fire laws on the part of the States.

The report says further:

> Present tax laws prevent reforestation of cut-over land and the perpetuation of existing forests by use. An annual tax upon the land itself, exclusive of the timber, and a tax upon the timber when cut is well adapted to actual conditions of forest investment and is practicable and certain. It is far better that forest land should pay a moderate tax permanently than that it should pay an excessive revenue temporarily and then cease to yield at all.

Second only in importance to good fire laws well enforced is the enactment of tax laws which will permit the perpetuation of existing forests by use.

LANDS.

With our increasing population the time is not far distant when the problem of supplying our people with food will become pressing. The possible additions to our arable area are not great, and it will become necessary to obtain much larger crops from the land, as is now done in more densely settled countries. To do this, we need better farm practice and better strains of wheat, corn, and other crop plants, with a reduction in losses from soil erosion and from insects, animals, and other enemies of agriculture. The United States Department of Agriculture is doing excellent work in these directions, and it should be liberally supported.

The remaining public lands should be classified and the arable lands disposed of to home makers. In their interest the timber and stone act and the commutation clause of the homestead act should be repealed, and the desert-land law should be modified in accordance with the recommendations of the Public Lands Commission.

The use of the public grazing lands should be regulated in such ways as to improve and conserve their value.

Rights to the surface of the public land should be separated from rights to forests upon it and to minerals beneath it, and these should be subject to separate disposal.

The coal, oil, gas, and phosphate rights still remaining with the Government should be withdrawn from entry and leased under conditions favorable for economic development.

MINERALS.

The accompanying reports show that the consumption of nearly all of our mineral products is increasing more rapidly than our population. Our mineral waste is about one-sixth of our product, or nearly $1,000,000 for each working day in the year. The loss of structural materials through fire is about another million a day. The loss of life in the mines is appalling. The larger part of these losses of life and property can be avoided.

Our mineral resources are limited in quantity and can not be increased or reproduced. With the rapidly increasing rate of consumption the supply will be exhausted while yet the nation is in its infancy unless better methods are devised or substitutes are found. Further investigation is urgently needed in order to improve methods and to develop and apply substitutes.

It is of the utmost importance that a bureau of mines be established in accordance with the pending bill to reduce the loss of life in mines and the waste of mineral resources and to investigate the methods and substitutes for prolonging the duration of our mineral supplies. Both the need and the public demand for such a bureau are rapidly becoming more urgent. It should cooperate with the States in supplying data to serve as a basis for state mine regulations. The establishment of this bureau will mean merely the transfer from other bureaus of work which it is agreed should be transferred and slightly enlarged and reorganized for these purposes.

CONCLUSIONS.

The joint conference already mentioned adopted two resolutions to which I call your special attention. The first was intended to promote cooperation between the States and the nation upon all of the great questions here discussed. It is as follows:

> *Resolved*, That a joint committee be appointed by the chairman, to consist of six members of state conservation commissions and three members of the National Conservation Commission, whose duty it shall be to prepare and present to the state and national commissions, and through them to the governors and the President, a plan for united action by all organizations concerned with the conservation of natural resources.
>
> (On motion of Governor Noel, of Mississippi, the chairman and secretary of the conference were added to and constituted a part of this committee.)

The second resolution of the joint conference to which I refer calls upon the Congress to provide the means for such cooperation. The principle of the community of interest among all our people in the great natural resources runs through the report of the National Conservation Commission and the proceedings of the joint conference. These resources, which form the common basis of our welfare, can be wisely developed, rightly used, and prudently conserved only by the common action of all the people, acting through their representatives in State and nation. Hence the fundamental necessity for cooperation. Without it we shall accomplish but little, and that little badly. The resolution follows:

> We also especially urge on the Congress of the United States the high desirability of maintaining a national commission on the conservation of the resources of the country, empowered to cooperate with state commissions to the end that every sovereign commonwealth and every section of the country may attain the high degree of prosperity and the sureness of perpetuity naturally arising in the abundant resources and the vigor, intelligence, and patriotism of our people.

In this recommendation I most heartily concur, and I urge that an appropriation of at least $50,000 be made to cover the expenses of the National Conservation Commission for necessary rent, assistance, and traveling expenses. This is a very small sum. I know of no other way in which the appropriation of so small a sum would result in so large a benefit to the whole nation.

THEODORE ROOSEVELT.

THE WHITE HOUSE, *January 22, 1909.*

LETTER OF THE CHAIRMAN OF THE NATIONAL CONSERVATION COMMISSION

TRANSMITTING THE

REPORT TO THE PRESIDENT

NATIONAL CONSERVATION COMMISSION,
Washington, January 11, 1909.

SIR: Herewith I have the honor to place in your hands the report of the National Conservation Commission, created by you June 8, 1908, to inquire into and advise you as to the condition of our natural resources, and to cooperate with other bodies created for similar purposes by the States.

The executive committee designated in your letter creating the commission organized on June 19 and outlined a plan for making an inventory of the natural resources of the United States. On July 1 work was undertaken, accordingly, with the cooperation of the bureaus of the federal departments, authorities of the different States, and representative bodies of the national industries. The results of this cooperative work are herewith submitted as appendixes of the commission's report.

The mass of material which constitutes the inventory has been summarized under the direction of the secretaries of the respective sections of the commission so as to assemble the most salient points of the inventory. At the first general meeting of the commission, on December 1, 1908, the summaries of the four sections of the commission were presented and were supplemented by personal statements of the experts in the several bureaus in the executive departments who had immediate charge of the inventory along their special lines of work. After the discussion of the summaries and statements the commission united in the report which is herewith submitted.

In view of the peculiarly valuable contributions and services rendered by the experts of the several departments, the commission at its closing session unanimously adopted the following resolutions:

> Whereas the commission, in the discharge of the duties committed to it, has been greatly aided by the patient labors and the ability and zeal of its secretary and the secretary of each of its four sections, and of the experts in the government service who lent their assistance in the collection of statistical and other data necessary to the elucidation and proper understanding of the subjects dealt with, and to the preparation of its report: Therefore
>
> *Resolved*, That the commission hereby makes cordial acknowledgment of its obligation to the gentlemen referred to and tenders them its thanks.
>
> *Resolved further*, That the secretary of the commission be directed to transmit to each of those who prepared papers and who appeared before the commission a copy of these resolutions.

In addition, I desire to call your special attention to the spirit and devotion of the gentlemen without whose services the making of the national inventory would have been impossible. Through their great interest in the task intrusted by you to the commission and to them, a great part of their work in connection with the inventory was performed outside the official hours. Furthermore, the material which they have prepared presents valuable information in connection with the work of the several executive departments which otherwise would not have been collected at this time. The assembling of this vast amount of material is largely due to Mr. Henry Gannett, whom you designated for this work, and to whose expert knowledge and power of generalization the commission owes more than it can repay.

In its cooperation "with other bodies created for similar purposes by the States," the National Conservation Commission has had most valuable assistance. Within the first month after the creation of the commission, the governors of 5 States had appointed conservation commissions, and an equal number of organizations of national scope had named conservation committees. At the time of the recent joint conservation conference 33 States and Territories had formed conservation commissions. The number has now increased to 36, with indications that nearly all of the remaining States will soon take similar action. The number of national organizations which have appointed conservation committees is 41.

The report herewith submitted was unanimously approved by the joint conservation conference. Further action was taken by the conference in authorizing a joint committee on cooperation, to be composed of six members of state conservation commissions and three members of the National Conservation Commission with its chairman and secretary. This committee is to devise ways and means for effective cooperation between all forces working for the conservation of natural resources. By this action the conservation movement enters the field of definite constructive work, for which its labors in ascertaining the country's present status and future outlook were simply preparatory.

Very respectfully,

GIFFORD PINCHOT,
Chairman.

The PRESIDENT,
The White House.

REPORT OF THE NATIONAL CONSERVATION COMMISSION

The duty of man to man, on which the integrity of nations must rest, is no higher than the duty of each generation to the next; and the obligation of the nation to each actual citizen is no more sacred than the obligation to the citizen to be, who, in turn, must bear the nation's duties and responsibilities.

In this country, blessed with natural resources in unsurpassed profusion, the sense of responsibility to the future has been slow to awaken. Beginning without appreciation of the measure or the value of natural resources other than land with water for commercial uses, our forefathers pushed into the wilderness and, through a spirit of enterprise which is the glory of the nation, developed other great resources. Forests were cleared away as obstacles to the use of the land; iron and coal were discovered and developed, though for years their presence added nothing to the price of the land; and through the use of native woods and metals and fuels, manufacturing grew beyond all precedent, and the country became a power among the nations of the world.

Gradually the timber growing on the ground and the iron and coal within the ground came to have a market value and were bought and sold as sources of wealth. Meanwhile, vast holdings of these resources were acquired by those of greater foresight than their neighbors before it was generally realized that they possessed value in themselves; and in this way large interests, assuming monopolistic proportions, grew up, with greater enrichment to their holders than the world had seen before, and with the motive of immediate profit, with no concern for the future or thought of the permanent benefit of country and people, a wasteful and profligate use of the resources began and has continued.

The waters, at first recognized only as aids to commerce in supplying transportation routes, were largely neglected. In time this neglect began to be noticed, and along with it the destruction and approaching exhaustion of the forests. This, in turn, directed attention to the rapid depletion of the coal and iron deposits and the misuse of the land.

The public conscience became awakened. Seeing the increased value and noting the destructive consumption and waste of the natural resources, men began to realize that the permanent welfare of the country as well as the prosperity of their offspring were at stake.

The newly awakened sense of duty found expression in a call by the President upon the governors of the States to meet him in conference, and in the declaration of this conference at its sessions in the White House in May, 1908. The action of the conference led to the appointment of the National Conservation Commission, with authority to collect information and cooperate with similar commissions appointed by the States in the great work of conserving the natural resources of the country.

In the growth of the country and gradual development of the natural resources there have been three noteworthy stages. The first stage was that of individual enterprise for personal and family benefit. It led to the conquest of the wilderness.

The next stage was that of collective enterprise, either for the benefit of communities or for the profit of individuals forming the communities. It led to the development of cities and States, and too often to the growth of great monopolies.

The third stage is the one we are now entering. Within it the enterprise is collective and largely cooperative, and should be directed toward the larger benefit of communities, States, and the people generally.

In the first stage the resources received little thought. In the second they were wastefully used. In the stage which we are entering wise and beneficial uses are essential, and the checking of waste is absolutely demanded.

Although the natural resources are interrelated they are unlike, and each class requires distinct treatment. The land is a fixed quantity which can not be materially increased, though its productivity and availability for the uses of man may be greatly augmented; the forests are variable in quantity and may be destroyed by fire, waste, and improvident use, or protected and improved in such way as to meet human necessities. Together the lands and the forests are improvable resources.

The minerals are limited in quantity and can not be increased or improved by anything which man may do. They are expendable resources.

The fresh waters are limited in quantity, though the supply is permanent. They form a naturally renewable resource which man may do nothing to increase, but may do much in the way of conservation and better utilization.

The treatment applied to each class should be adapted to its own fullest development and best utilization and to those of the other classes of resources.

The wastes which most urgently require checking vary widely in character and amount. The most reprehensible waste is that of destruction, as in forest fires, uncontrolled flow of gas and oil, soil wash, and abandonment of coal in the mines. This is attributable, for the most part, to ignorance, indifference, or false notions of economy, to rectify which is the business of the people collectively.

Nearly as reprehensible is the waste arising from misuse, as in the consumption of fuel in furnaces and engines of low efficiency, the loss of water in floods, the employment of ill-adapted structural materials, the growing of ill-chosen crops, and the perpetuation of inferior stocks of plants and animals, all of which may be remedied.

Reprehensible in less degree is the waste arising from nonuse. Since the utilization of any one resource is necessarily progressive and dependent on social and industrial conditions and the concurrent development of other resources, nonuse is sometimes unavoidable.

It becomes reprehensible when it affects the common welfare and entails future injury. Then, it should be rectified in the general interest.

For the prevention of waste the most effective means will be found in the increase and diffusion of knowledge, from which is sure to result an aroused public sentiment demanding prevention. The people have the matter in their own hands. They may prevent or limit the destruction of resources and restrain misuse through the enactment and enforcement of appropriate state and federal laws.

At every stage in the growth of our country, strong men grew stronger through the exercise of nation building, and their intelligence and patriotism grew with their strength. The spirit and vigor of our people are the chief glory of the republic. Yet even as we have neglected our natural resources, so have we been thoughtless of life and health. Too long have we overlooked that grandest of our resources, human life. Natural resources are of no avail without men and women to develop them, and only a strong and sound citizenship can make a nation permanently great. We can not too soon enter on the duty of conserving our chief source of strength by the prevention of disease and the prolongation of life.

Wastes reduced and resources saved are the first but not the last object of conservation. The material resources have an additional value when their preservation adds to the beauty and habitability of the land. Ours is a pleasant land in which to dwell. To increase its beauty and augment its fitness can not but multiply our pleasure in it and strengthen the bonds of our attachment.

In the conservation of all the resources of the country the interest of the present and all future generations is concerned, and in this great work—involving the welfare of the citizen, the family, the community, the state, and the nation—our dual system of government, state and federal, should be brought into harmonious cooperation and collaboration.

MINERALS.

The mineral production of the United States for 1907 exceeded $2,000,000,000, and contributed 65 per cent of the total freight traffic of the country. The waste in the extraction and treatment of mineral products during the same year was equivalent to more than $300,000,000.

The production for 1907 included 395,000,000 tons of bituminous and 85,000,000 tons of anthracite coal, 166,000,000 barrels of petroleum, 52,000,000 tons of iron ore, 2,500,000 tons of phosphate rock, and 869,000,000 pounds of copper. The values of other mineral products during the same year included clay products, $162,000,000; stone, $71,000,000; cement, $56,000,000; natural gas, $53,000,000; gold, $90,000,000; silver, $37,000,000; lead, $39,000,000, and zinc, $26,000,000.

The available and easily accessible supplies of coal in the United States aggregate approximately 1,400,000,000,000 tons. At the present increasing rate of production this supply will be so depleted as to approach exhaustion before the middle of the next century.

The known supply of high-grade iron ores in the United States approximates 4,788,150,000 tons, which at the present increasing rate of consumption can not be expected to last beyond the middle of the present century. In addition to this, there are assumed to be 75,116,070,000 tons of lower grade iron ores which are not available for use under existing conditions.

The supply of stone, clay, cement, lime, sand, and salt is ample, while the stock of the precious metals and of copper, lead, zinc, sulphur, asphalt, graphite, quicksilver, mica, and the rare metals can not well be estimated, but is clearly exhaustible within one to three centuries unless unexpected deposits be found.

The known supply of petroleum is estimated at 15,000,000,000 to 20,000,000,000 barrels, distributed through six separate fields having an aggregate area of 8,900 square miles. The production is rapidly increasing, while the wastes and the loss through misuse are enormous. The supply can not be expected to last beyond the middle of the present century.

The known natural-gas fields aggregate an area of 9,000 square miles, distributed through 22 States. Of the total yield from these fields during 1907, 400,000,000,000 cubic feet, valued at $62,000,000, were utilized, while an equal quantity was allowed to escape into the air. The daily waste of natural gas—the most perfect known fuel—is over 1,000,000,000 cubic feet, or enough to supply every city in the United States of over 100,000 population.

Phosphate rock, used for fertilizer, represents the slow accumulation of organic matter during past ages. In most countries it is scrupulously preserved; in this country it is extensively exported, and largely for this reason its production is increasing rapidly. The original supply can not long withstand the increasing demand.

The consumption of nearly all our mineral products is increasing far more rapidly than our population. In many cases the waste is increasing more rapidly than the number of our people. In 1776 but a few dozen pounds of iron were in use by the average family; now our annual consumption of high-grade ore is over 1,200 pounds per capita. In 1812 no coal was used; now the consumption is over 5 tons and the waste nearly 3 tons per capita.

While the production of coal is increasing enormously, the waste and loss in mining are diminishing. At the beginning of our mineral development the coal abandoned in the mine was two or three times the amount taken out and used. Now the mine waste averages little more than half the amount saved. The chief waste is in imperfect combustion in furnaces and fire boxes. Steam engines utilize on the average about 8 per cent of the thermal energy of the coal. Internal-combustion engines utilize less than 20 per cent, and in electric lighting far less than 1 per cent of the thermal energy is rendered available.

With increasing industries new mineral resources become available from time to time. Some lignites and other low-grade coals are readily gasified and, through the development of internal-combustion engines may be made to check the consumption of high-grade coals.

Peat is becoming important; it is estimated that 14,000,000,000 tons are available in the United States. Its value is enhanced because of distribution through States generally remote from the fields of coal, oil, and natural gas.

The uses of all our mineral resources are interdependent. This is especially true of coal and iron, of which neither can be produced or used without aid from the other, and in the production or reduction of all other minerals both coal and iron are employed. The same standard minerals are necessary to the development of power, of which the use is increasing more rapidly than that of any other commodity.

The building operations of the country now aggregate about $1,000,000,000 per year. The direct and indirect losses from fire in the United States during 1907 approximated $450,000,000, or one-half the cost of construction. Of this loss four-fifths, or an average of $1,000,000 per day, could be prevented, as shown by comparison with the standards of construction and fire losses in the larger European countries.

So far as the ores are taken from the mines and reduced to metals, these resources are capitalized; but after thus being changed to a more valuable form they should be so used as to reduce to a minimum the loss by rust, electrolytic action, and other wastes.

There is urgent need for greater safety to the miner. The loss of life through mine accidents is appalling, and preventive measures can not be taken too soon.

The National Government should exercise such control of the mineral fuels and phosphate rocks now in its possession as to check waste and prolong our supply.

While the distribution and quantity of most of our important mineral substances are known in a general way, there is imperative need for further surveys and investigations and for researches concerning the less-known minerals.

LANDS.

The total land area of continental United States is 1,920,000,000 acres. Of this but little more than two-fifths is in farms, and less than one-half of the farm area is improved and made a source of crop production. We have nearly 6,000,000 farms; they average 146 acres each. The value of the farms is nearly one-fourth the wealth of the United States. There are more than 300,000,000 acres of public grazing land. The number of persons engaged in agricultural pursuits is more than 10,000,000.

We grow one-fifth of the world's wheat crop, three-fifths of its cotton crop, and four-fifths of its corn crop. We plant nearly 50,000,000 acres of wheat annually, with an average yield of about 14 bushels per acre; 100,000,000 acres of corn, yielding an average of 25 bushels per acre; and 30,000,000 acres of cotton, yielding about 12,000,000 bales.

We had on January 1, 1908, 71,000,000 cattle, worth $1,250,000,000; 54,000,000 sheep, worth $211,000,000; and 56,000,000 swine, worth $339,000,000. The census of 1900 showed $137,000,000 worth of poultry in this country, which produced in 1899, 293,000,000 dozen eggs.

There has been a slight increase in the average yield of our great staple farm products, but neither the increase in acreage nor the yield per acre has kept pace with our increase in population. Within a century we shall probably have to feed three times as many people as now; and the main bulk of our food supply must be grown on our own soil.

The area of cultivated land may possibly be doubled. In addition to the land awaiting the plow, 75,000,000 acres of swamp land can be reclaimed, 40,000,000 acres of desert land irrigated, and millions of acres of brush and wooded land cleared. Our population will increase continuously, but there is a definite limit to the increase of our cultivated acreage. Hence we must greatly increase the yield per acre. The average yield of wheat in the United States is less than 14 bushels per acre, in Germany 28 bushels, and in England 32 bushels. We get 30 bushels of oats per acre, England nearly 45, and Germany more than 47. Our soils are fertile, but our mode of farming neither conserves the soil nor secures full crop returns. Soil fertility need not be diminished, but may be increased. The large yields now obtained from farms in Europe which have been cultivated for a thousand years prove this conclusively. Proper management will double our average yield per acre. The United States can grow the farm products needed by a population more than three times as great as our country now contains.

The greatest unnecessary loss of our soil is preventable erosion. Second only to this is the waste, nonuse, and misuse of fertilizer derived from animals and men.

The losses to farm products due to injurious mammals is estimated at $130,000,000 annually; the loss through plant diseases reaches several hundred million dollars; and the loss through insects is reckoned at $659,000,000. The damage by birds is balanced by their beneficent work in destroying noxious insects. Losses due to the elements are large, but no estimate has been made of them. Losses to live stock from these causes are diminishing because of protection and feeding during winter. The annual losses from disease among domestic animals are: Horses, 1.8 per cent; cattle, 2 per cent; sheep, 2.2 per cent, and swine, 5.1 per cent. Most of these farm losses are preventable.

There is a tendency toward consolidation of farm lands. The estimated area of abandoned farms is 16,000 square miles, or about 3 per cent of the improved land. The causes of abandonment differ in different parts of the country. Where most prevalent, it is caused principally by erosion and exhaustion of the soil.

The product of the fisheries of the United States has an annual value of $57,000,000. Fish culture is carried on by the nation and the States on an enormous scale. Most of the more important food species are propagated, and several species are maintained in that way. Fish from forest waters furnish $21,000,000 worth of food yearly, a supply dependent on the preservation of the forests.

Our wild game and fur-bearing animals have been largely exterminated. To prevent their complete extinction the States and the United States have taken in hand their protection, and their numbers are now increasing. Forest game yields over $10,000,000 worth of food each year.

With game birds the story is much the same—wanton destruction until the number has been greatly reduced, followed in recent years by wise protection, which in some cases allows the remnant to survive and even to increase.

Each citizen of the United States owns an equal undivided interest in about 387,000,000 acres of public lands, exclusive of Alaska and the insular possessions. Besides this there are about 235,000,000 acres of national forests, national parks, and other lands devoted to public use.

Good business sense demands that a definite land policy be formulated. The National Conservation Commission believes that the following will serve as a basis therefor:

1. Every part of the public lands should be devoted to the use which will best subserve the interests of the whole people.
2. The classification of all public lands is necessary for their administration in the interests of the people.
3. The timber, the minerals, and the surface of the public lands should be disposed of separately.
4. Public lands more valuable for conserving water supply, timber, and natural beauties or wonders than for agriculture should be held for the use of the people from all except mineral entry.
5. Title to the surface of the remaining nonmineral public lands should be granted only to actual home makers.
6. Pending the transfer of title to the remaining public lands they should be administered by the Government and their use should be allowed in a way to prevent or control waste and monopoly.

The present public-land laws as a whole do not subserve the best interests of the nation. They should be modified so far as may be required to bring them into conformity with the foregoing outline of policy.

FORESTS.

Next to our need of food and water comes our need of timber.

Our industries which subsist wholly or mainly upon wood pay the wages of more than 1,500,000 men and women.

Forests not only grow timber, but they hold the soil and they conserve the streams. They abate the wind and give protection from excessive heat and cold. Woodlands make for the fiber, health, and happiness of the citizen and the nation.

Our forests now cover 550,000,000 acres, or about one-fourth of the United States. The original forests covered not less than 850,000,000 acres.

Forests publicly owned contain one-fifth of all our standing timber. Forests privately owned contain four-fifths of the standing timber. The timber privately owned is not only four times that publicly owned, but is generally more valuable.

Forestry is now practiced on 70 per cent of the forests publicly owned and on less than 1 per cent of the forests privately owned, or on only 18 per cent of the total area of forests.

The yearly growth of wood in our forests does not average more than 12 cubic feet per acre. This gives a total yearly growth of less than 7,000,000,000 cubic feet.

We have 200,000,000 acres of mature forests, in which yearly growth is balanced by decay; 250,000,000 acres partly cut over or burned over, but restocking naturally with enough young growth to produce a merchantable crop, and 100,000,000 acres cut over and burned over, upon which young growth is lacking or too scanty to make merchantable timber.

We take from our forests yearly, including waste in logging and in manufacture, 23,000,000,000 cubic feet of wood. We use each year 100,000,000 cords of firewood; 40,000,000,000 feet of lumber; more than 1,000,000,000 posts, poles, and fence rails; 118,000,000 hewn ties; 1,500,000,000 staves; over 133,000,000 sets of heading; nearly 500,000,000 barrel hoops; 3,000,000 cords of native pulp wood; 165,000,000 cubic feet of round mine timbers, and 1,250,000 cords of wood for distillation.

Since 1870 forest fires have destroyed a yearly average of 50 lives and $50,000,000 worth of timber. Not less than 50,000,000 acres of forest is burned over yearly. The young growth destroyed by fire is worth far more than the merchantable timber burned.

One-fourth of the standing timber is lost in logging. The boxing of long-leaf pine for turpentine has destroyed one-fifth of the forests worked. The loss in the mill is from one-third to two-thirds of the timber sawed. The loss of mill product in seasoning and fitting for use is from one-seventh to one-fourth.

Of each 1,000 feet which stood in the forest, an average of only 320 feet of lumber is used.

We take from our forests each year, not counting the loss by fire, three and a half times their yearly growth. We take 40 cubic feet per acre for each 12 cubic feet grown; we take 260 cubic feet per capita, while Germany uses 37 and France 25 cubic feet.

We tax our forests under the general property tax, a method abandoned long ago by every other great nation. Present tax laws prevent reforestation of cut-over land and the perpetuation of existing forests by use.

Great damage is done to standing timber by injurious forest insects. Much of this damage can be prevented at small expense.

To protect our farms from wind and to reforest land best suited for forest growth will require tree planting on an area larger than Pennsylvania, Ohio, and West Virginia combined. Lands so far successfully planted make a total area smaller than Rhode Island; and year by year, through careless cutting and fires, we lower the capacity of existing forests to produce their like again, or else totally destroy them.

In spite of substitutes we shall always need much wood. So far our use of it has steadily increased. The condition of the world's supply of timber makes us already dependent upon what we produce. We send out of our country one and a half times as much timber as we bring in. Except for finishing woods, relatively small in amount, we must grow our own supply or go without. Until we pay for our lumber what it costs to grow it, as well as what it costs to log and saw, the price will continue to rise.

The preservation by use, under the methods of practical forestry, of all public forest lands, either in state or federal ownership, is essential to the permanent public welfare. In many forest States the acquirement of additional forest lands as state forests is necessary to the best interests of the States themselves.

The conservation of our mountain forests, as in the Appalachian system, is a national necessity. These forests are required to aid in the regulation of streams used for navigation and other purposes. The conservation of these forests is impracticable through private enterprise alone, by any State alone, or by the Federal Government alone. Effective and immediate cooperation between these three agencies is essential. Federal ownership of limited protective areas upon important watersheds, effective state fire patrol, and the cooperation of private forest owners are all required.

The true remedy for unwise tax laws lies not in laxity in their application nor in special exemptions, but in a change in the method of taxation. An annual tax upon the land itself, exclusive of the value of the timber, and a tax upon the timber when cut, is well adapted to actual conditions of forest investment, and is practicable and certain. It is far better that forest land should pay a moderate tax permanently than that it should pay an excessive revenue temporarily and then cease to pay at all.

Forests in private ownership can not be conserved unless they are protected from fire. We need good fire laws, well enforced. Fire control is impossible without an adequate force of men whose sole duty is fire patrol during the dangerous season.

The conservative use of the forest and of timber by American citizens will not be general until they learn how to practice forestry. Through a vigorous national campaign in education, forestry has taken root in the great body of American citizenship. The basis already exists upon which to build a structure of forest conservation which will endure. This needs the definite commitment of state governments and the Federal Government to their inherent duty of teaching the people how to care for their forests. The final responsibility, both for investigative work in forestry and for making its results known, rests upon the States and upon the nation.

By reasonable thrift, we can produce a constant timber supply beyond our present need, and with it conserve the usefulness of our streams for irrigation, water supply, navigation, and power.

Under right management our forests will yield over four times as much as now. We can reduce waste in the woods and in the mill at least one-third, with present as well as future profit. We can perpetuate the naval-stores industry. Preservative treatment will reduce by one-fifth the quantity of timber used in the water or in the ground. We can practically stop forest fires at a cost yearly of one-fifth the value of the merchantable timber burned.

We shall suffer for timber to meet our needs until our forests have had time to grow again. But if we act vigorously and at once we shall escape permanent timber scarcity.

WATERS.

The sole source of our fresh water is rainfall, including snow. From this source all running, standing, and ground waters are derived. The habitability of the country depends on these waters. Our mean annual rainfall is about 30 inches; the quantity about 215,000,000,000,000 cubic feet per year, equivalent to ten Mississippi rivers.

Of the total rainfall, over half is evaporated; about a third flows into the sea; the remaining sixth is either consumed or absorbed. These portions are sometimes called, respectively, the fly-off, the run-off, and the cut-off. They are partly interchangeable. About a third of the run-off, or a tenth of the entire rainfall, passes through the Mississippi. The run-off is increasing with deforestation and cultivation.

Of the 70,000,000,000,000 cubic feet annually flowing into the sea, less than 1 per cent is retained and utilized for municipal and community supply; less than 2 per cent (or some 10 per cent of that in the arid and semiarid regions) is used for irrigation; perhaps 5 per cent is used for navigation, and less than 5 per cent for power.

For municipal and community water supply there are protected catchment areas aggregating over 1,000,000 acres, and over $250,000,000 are invested in waterworks, with nearly as much more in the appurtenant catchment areas and other lands. The population so supplied approaches 10,000,000, and the annual consumption is about 37,500,000,000 cubic feet. The better managed systems protect the catchment areas by forests and grass; the water is controlled and the storm product used, but there is large waste after the water enters the mains.

For irrigation it is estimated that there are $200,000,000 invested in dams, ditches, reservoirs, and other works for the partial control of the waters, and that 1,500,000,000,000 cubic feet are annually diverted to irrigable lands, aggregating some 20,000 square miles. Except in some cases through forestry, few catchment areas are controlled, and few reservoirs are large enough to hold the storm waters. The waste in the public and private projects exceeds 60 per cent, while no more than 25 per cent of the water actually available for irrigation of the arid lands is restrained and diverted.

There are in continental United States 287 streams navigated for an aggregate of 26,226 miles, and as much more navigable if improved. There are also 45 canals, aggregating 2,189 miles, besides numerous abandoned canals. Except through forestry in recent years, together with a few reservoirs and canal locks and movable dams, there has been little effort to control headwaters or catchment areas in the interests of navigation, and none of our rivers are navigated to more than a small fraction even of their effective low-water capacity.

The water power now in use is 5,250,000 horsepower; the amount running over government dams and not used is about 1,400,000 horsepower; the amount reasonably available equals or exceeds the entire mechanical power now in use, or enough to operate every mill, drive every spindle, propel every train and boat, and light every city, town, and village in the country. While the utilization of water power ranks among our most recent and most rapid industrial developments, little effort has been made to control catchment areas or storm waters in any large way for power, though most plants effect local control through reservoirs and other works. Nearly all the freshet and flood water runs to waste, and the low waters which limit the efficiency of power plants are increasing in frequency and duration with the increasing flood run-off.

The practical utility of streams for both navigation and power is measured by the effective low-water stage. The volume carried when the streams rise above this stage is largely wasted and often does serious damage. The direct yearly damage by floods since 1900 has increased steadily from $45,000,000 to over $238,000,000. The indirect loss through depreciation of property is great, while a large loss arises in impeded traffic through navigation and terminal transfers.

The freshets are attended by destructive soil erosion. The soil matter annually carried into lower rivers and harbors or into the sea is computed at 783,000,000 tons. Soil wash reduces by 10 or 20 per cent the productivity of upland farms and increases channel cutting and bar building in the rivers. The annual loss to the farms alone is fully $500,000,000, and large losses follow the fouling of the waters and the diminished navigability of the streams.

Through imperfect control of the running waters lowlands are temporarily or permanently flooded. It is estimated that there are in mainland United States about 75,000,000 acres of overflow and swamp lands requiring drainage; that by systematic operation these can be drained at moderate expense, and that they would then be worth two or three times the present value and cost of drainage, and would furnish homes for 10,000,000 people.

It is estimated that the quantity of fresh water stored in lakes and ponds (including the American portion of the Great Lakes) is about 600,000,000,000,000 cubic feet, equivalent to three years' rainfall or eight years' run-off. Some 6,000,000 of our people draw their water supply from lakes.

A large part of that half of the annual rainfall not evaporated lodges temporarily in the soil and earth. It is estimated that the ground water to the depth of 100 feet averages 16⅔ per cent of the earth volume, or over 1,400,000,000,000,000 cubic feet, equivalent to seven years' rainfall or twenty years' run-off. This subsurface reservoir is the essential basis of agriculture and other industries and is the chief natural resource of the country. It sustains forests and all other crops and supplies the perennial springs and streams and wells used by four-fifths of our population and nearly all our domestic animals. Its quantity is diminished by the increased run-off due to deforestation and injudicious farming. Although the volume of the available ground water is subject to control by suitable treatment of the surface, little effort has been made to retain or increase it, and it is probable that fully 10 per cent of this rich resource has been wasted since settlement began. The water of the strata below 100 feet supplies artesian and deep wells, large springs, and thermal and mineral waters. It can be controlled only through the subsurface reservoir.

Of the 35,000,000,000,000 cubic feet of cut-off, the chief share is utilized by natural processes or by agriculture and related industries. On an average the plant tissue of annual growths is three-fourths and of perennial growths three-eighths water; of human and stock food over 80 per cent is water, and in animal tissue the ratio is about the same; and since water is the medium for organic circulation, the plants and animals of the country yearly require an amount many times exceeding their aggregate volume. Even in the more humid sections of the country the productivity of the soil and the possible human population would be materially increased by a greater rainfall, leaving a larger margin for organic and other chemical uses. Except through agriculture and forestry little general effort is made to control the annual cut-off, although some farmers in arid regions claim to double or triple the crop from given soil by supplying water just when needed and withholding it when not required.

Water is like other resources in that its quantity is limited. It differs from such mineral resources as coal and iron, which once used are gone forever, in that the supply is perpetual; and it differs from such resources as soils and forests, which are capable of renewal or improvement, in that it can not be augmented in quantity, though like all other resources it can be better utilized.

It is now recognized by statesmen and experts that navigation is interdependent with other uses of the streams; that each stream is essentially a unit from its source to the sea; and that the benefits of a comprehensive system of waterway improvement will extend to all the people in the several sections and States of the country.

It is also recognized, through the unanimous declaration of the governors of the States and Territories adopted in conference with the leading jurists and statesmen and experts of the country, that in the use of the natural resources the independent States are interdependent, and bound together by ties of mutual benefits, responsibilities, and duties.

It has recently been declared by a majority of our leading statesmen that it is an imperative duty to enter upon a systematic improvement, on a large and comprehensive plan, just to all portions of the country, of the waterways and harbors and Great Lakes, whose natural adaptability to the increasing traffic of the land is one of the greatest gifts of a benign Providence; while the minority indorsed the movement for control of the waterways still more specifically and in equally emphatic terms.

Within recent months it has been recognized and demanded by the people, through many thousand delegates from all States assembled in convention in different sections of the country, that the waterways should and must be improved promptly and effectively as a means of maintaining national prosperity.

The first requisite for waterway improvement is the control of the waters in such manner as to reduce floods and regulate the regimen of the navigable rivers. The second requisite is development of terminals and connections in such manner as to regulate commerce.

In considering the uses and benefits to be derived from the waters, the paramount use should be water supply; next should follow navigation in humid regions and irrigation in arid regions. The development of power on the navigable and source streams should be coordinated with the primary and secondary uses of the waters. Other things equal, the development of power should be encouraged, not only to reduce the drain on other resources, but because properly designed reservoirs and power plants retard the run-off and so aid in the control of the streams for navigation and other uses.

Broad plans should be adopted providing for a system of waterway improvement extending to all uses of the waters and benefits to be derived from their control, including the clarification of the water and abatement of floods for the benefit of navigation; the extension of irrigation; the development and application of power; the prevention of soil wash; the purification of streams for water supply; and the drainage and utilization of the waters of swamp and overflow lands.

To promote and perfect these plans scientific investigations, surveys, and measurements should be continued and extended, especially the more accurate determination of rainfall and evaporation, the investigation and measurement of ground water, the gauging of streams and determination of sediment, and topographic surveys of catchment areas and sites available for control of the waters for navigation and related purposes.

NATIONAL EFFICIENCY.

Since the greatest of our national assets is the health and vigor of the American people, our efficiency must depend on national vitality even more than on the resources of the minerals, lands, forests, and waters.

The average length of human life in different countries varies from less than twenty-five to more than fifty years. This span of life is increasing wherever sanitary science and preventive medicine are applied. It may be greatly extended.

Our annual mortality from tuberculosis is about 150,000. Stopping three-fourths of the loss of life from this cause, and from typhoid and other prevalent and preventable diseases, would increase our average length of life over fifteen years.

There are constantly about 3,000,000 persons seriously ill in the United States, of whom 500,000 are consumptives. More than half this illness is preventable.

If we count the value of each life lost at only $1,700 and reckon the average earning lost by illness as $700 per year for grown men, we find that the economic gain from mitigation of preventable disease in the United States would exceed $1,500,000,000 a year. In addition, we would decrease suffering and increase happiness and contentment among the people. This gain, or the lengthening and strengthening of life which it measures, can be secured through medical investigation and practice, school and factory hygiene, restriction of labor by women and children, the education of the people in both public and private hygiene, and through improving the efficiency of our health service—municipal, state, and national. The National Government has now several agencies exercising health functions which only need to be concentrated to become coordinated parts of a greater health service worthy of the nation.

The inventory of our natural resources made by your commission with the vigorous aid of all federal agencies concerned, of many States, and of a great number of associated and individual cooperators, furnishes a safe basis for general conclusions as to what we have, what we use and waste, and what may be the possible saving. But for none of the great resources of the farm, the mine, the forest, and the stream do we yet possess knowledge definite or wide enough to insure methods of use which will best conserve them.

In order to conserve a natural resource, we must know what that resource is by taking stock. We greatly need a more complete inventory of our natural resources; and this can not be made except through the active cooperation of the States with the nation.

The permanent welfare of the nation demands that its natural resources be conserved by proper use. To this end the States and the nation can do much by legislation and example. By far the greater part of these resources is in private hands. Private ownership of natural resources is a public trust; they should be administered in the interests of the people as a whole. The States and nation should lead rather than follow in the conservative and efficient use of property under their immediate control. But their first duty is to gather and distribute a knowledge of our natural resources and of the means necessary to insure their use and conservation, to impress the body of the people with the great importance of the duty, and to promote the cooperation of all. No agency, state, federal, corporate, or private, can do the work alone.

Finally, the conservation of our resources is an immediate and vital concern. Our welfare depends on conservation. The pressing need is for a general plan under which citizens, States, and nation may unite in an effort to achieve this great end. The lack of cooperation between the States themselves, between the States and the nation, and between the agencies of the National Government, is a potent cause of the neglect of conservation among the people. An organization through which all agencies—state, national, municipal, associate, and individual—may unite in a common effort to conserve the foundations of our prosperity is indispensable to the welfare and progress of the nation. To that end the immediate creation of a national agency is essential. Many States and associations of citizens have taken action by the appointment of permanent conservation commissions. It remains for the nation to do likewise, in order that the States and the nation, associations and individuals, may join in the accomplishment of this great purpose.

Accompanying this report, and transmitted as a part thereof, are detailed statements by the secretaries of the several sections, and many papers and illustrations prepared by experts at the request of your commission.

GIFFORD PINCHOT, *Chairman.*
W J MCGEE,
Secretary, Section of Waters.
OVERTON W. PRICE,
Secretary, Section of Forests.
GEORGE W. WOODRUFF,
Secretary, Section of Lands.
J. A. HOLMES,
Secretary, Section of Minerals.

Attest:
THOMAS R. SHIPP,
Secretary to the Commission.

DECEMBER 7, 1908.

JOINT CONSERVATION CONFERENCE

SUPPLEMENTARY REPORT

This joint conservation conference, in session assembled in the city of Washington on this 10th day of December, in the year 1908, representing the several States and Territories of the United States through governors of States, state conservation commissions, delegates, and representatives of state and national organizations dealing with natural resources, does hereby resolve and declare:

Having heard the report of the National Conservation Commission read, and having fully deliberated thereon, we hereby indorse the said report as a wise, just, and patriotic statement of the resources of the nation, of the thoughtless and profligate manner in which some of these resources have been and are being wasted, and of the urgent need for their conservation in the interests of this and future generations, to the end that the prosperity and perpetuity of the nation may be assured.

We especially approve of the principle of cooperation among the States and between these and the Federal Government laid down in that report and in the earlier report of the Inland Waterways Commission, and urge both state and federal legislatures to enact such laws as may be necessary to extend and apply such cooperation in all matters pertaining to the use and conservation of our resources.

We especially commend and urge the adoption of the policy of separate disposal of the surface rights, timber rights, and mineral rights on the remaining public lands of the United States; and we approve the disposal of mineral rights by lease only, and the disposal of timber rights only under conditions insuring proper cutting and logging with a view to the protection of growing timber and the watersheds and headwaters of streams used for navigation and other interstate purposes.

We also especially approve and indorse the proposition that all uses of the waters and all portions of each waterway should be treated as interrelated; and we emphatically urge prompt and effective legislation providing for the immediate and proper development of the waterways of the country for navigation, water supply, and other interstate uses, preferably by direct federal appropriations; otherwise by the issue of bonds.

Fully approving the policy of improving the waterways of the country for navigation and other interstate uses of the waters, we urge the prompt adoption of the broad plan recommended by the Inland Waterways Commission for waterway development under an executive board or commission appointed by and acting under the direction of the President of the United States.

Approving those portions of the report pointing out the need for continued investigation and more extended scientific research, we also urge that this policy of gaining more definite and specific knowledge relating to our resources be adopted by the several States no less than by the Federal Government.

Especially commending the portions of the report dealing with diminished national efficiency due to disease and premature death among our citizens, we urge the adoption of the policy of protecting life and health by States, municipalities, and communities, no less than by the Federal Government; and we urge further investigation of all other means whereby the efficiency of individual citizens, and hence of the State and nation may be increased.

We favor the maintenance of conservation commissions in every State, to the end that each Commonwealth may be aided and guided in making the best use of those abundant resources with which it has been blessed.

We also especially urge on the Congress of the United States the high desirability of maintaining a national commission on the conservation of the resources of the country, empowered to cooperate with state commissions, to the end that every sovereign Commonwealth and every section of the country may attain the high degree of prosperity and the sureness of perpetuity naturally arising in the abundant resources and the vigor, intelligence, and patriotism of our people.

Personnel of the Conference

The Joint Conservation Conference was composed of the following:

Hon. Wilford B. Hoggatt, governor of Alaska.
Hon. Joseph H. Kibbey, governor of Arizona.
Hon. X. O. Pindall, acting governor of Arkansas.
Hon. Rollin S. Woodruff, governor of Connecticut.
Hon. H. B. F. Macfarland, chairman Board of Commissioners, District of Columbia.
Hon. Preston Lea, governor of Delaware.
Hon. Napoleon B. Broward, governor of Florida.
Hon. Hoke Smith, governor of Georgia.
Hon. W. F. Frear, governor of Hawaii.
Hon. Charles S. Deneen, governor of Illinois.
Hon. Walter R. Stubbs, governor-elect of Kansas.
Hon. Jared T. Sanders, governor of Louisiana.
Hon. Austin L. Crothers, governor of Maryland.
Hon. Curtis Guild, jr., governor of Massachusetts.
Hon. Fred M. Warner, governor of Michigan.
Hon. John A. Johnson, governor of Minnesota.
Hon. E. F. Noel, governor of Mississippi.
Hon. George Curry, governor of New Mexico.
Hon. John Burke, governor of North Dakota.
Hon. George E. Chamberlain, governor of Oregon.
Hon. Régis H. Post, governor of Porto Rico.
Hon. Martin F. Ansel, governor of South Carolina.
Senator William C. Edwards, representative of Canada.
Hon. R. H. Campbell, representative of Canada.
Mr. Andrew Carnegie.
Mr. John Mitchell.
Dr. Albert Shaw, editor Review of Reviews.
Personal representatives of governors:
    Mr. J. C. Needham, California.
    Mr. William G. Evans, Colorado.
    Hon. Eugene Hale, Maine.
    Col. John A. Ockerson, Missouri.
    Hon. Francis G. Newlands, Nevada.

Personal representatives of governors—Continued.

- Mr. Philip W. Ayres, New Hampshire.
- Hon. James S. Whipple, New York.
- Hon. Rosewell Page, Virginia.
- Hon. William Irvine, Wisconsin.
- Hon. Charles R. Van Hise, Wisconsin.
- Hon. William E. Mullen, Wyoming.

Representatives of the States:

- **Alabama—**
  - Hon. W. P. Lay, chairman conservation commission.
  - Hon. Frank H. Lathrop, member conservation commission.
  - Mr. J. B. Powell, member conservation commission.
- **California—**
  - Mr. Francis Cuttle, member conservation commission.
  - Mr. Frank H. Short, member conservation commission.
  - Mrs. Lovell White, member conservation commission.
  - Mr. Grant Conard.
- **Colorado—**
  - Hon. Simon Guggenheim, U. S. Senator from Colorado.
  - Mr. I. N. Stevens, member conservation commission.
  - Mr. Clarence P. Dodge, member conservation commission.
  - Mr. Ellsworth Bethel, member conservation commission.
  - Mr. Brooks Irlone.
- **Connecticut—**
  - Mr. Albert N. Abbee.
  - Mr. R. T. Crane.
- **Delaware—**
  - Hon. Benjamin Nields, member conservation commission.
- **Florida—**
  - Hon. William H. Milton, U. S. Senator from Florida, and chairman conservation commission.
  - Hon. Duncan U. Fletcher, member conservation commission.
- **Georgia—**
  - Mr. John A. Betjiman, member conservation commission.
- **Illinois—**
  - Hon. Isham Randolph, chairman conservation commission.
  - Dr. H. Foster Bain, member conservation commission.
  - Dr. Cyril C. Hopkins, member conservation commission.
  - Mr. Glenn W. Traer, member conservation commission.
- **Indiana—**
  - Hon. Henry Riesenberg, chairman conservation commission.
  - Hon. Chas. S. Bash, member conservation commission.
  - Mr. Joseph D. Oliver, member conservation commission.
  - Mr. E. W. Wickey, member conservation commission.
- **Kentucky—**
  - Mr. John B. Atkinson, member proposed conservation commission.
  - Mr. Wm. R. Belknap, member proposed conservation commission.
  - Hon. D. C. Edwards, member proposed conservation commission.
  - Mr. Fred W. Keisker, member proposed conservation commission.
  - Mr. F. C. Nunemacher, member proposed conservation commission.
  - Mr. J. C. Tomlin, member proposed conservation commission.
  - Mr. J. B. Bennett.
  - Gen. John B. Castleman.
  - Mr. A. D. James.
  - Mr. John W. Langley.
  - Col. A. T. McDonald.
  - Mr. Clifton J. Waddill.
- **Louisiana—**
  - Hon. Henry E. Hardtner, chairman conservation commission.
  - Hon. Harry P. Gamble, secretary conservation commission.
  - Maj. F. M. Kerr, member conservation commission.
- **Maryland—**
  - Mr. Bernard N. Baker, chairman conservation commission.
  - Prof. William Bullock Clark, member conservation commission.
  - Mr. Edward Hirsch, member conservation commission.
- **Massachusetts—**
  - Prof. Frank W. Rane, chairman conservation commission.

Representatives of the States—Continued.

Michigan—
- Hon. Wm. H. Rose, chairman forestry commission.
- Hon. W. B. Mershon, member forestry commission.
- Hon. Wm. F. Knox.
- Hon. Huntley Russell, commissioner of the state land office.

Minnesota—
- Hon. F. B. Lynch.
- Mr. P. H. Nelson.
- Mr. S. D. Works.

Mississippi—
- Prof. H. L. Whitfield.

Missouri—
- Mr. W. K. Kavanaugh, chairman commission on waterways.
- Dr. Herman Von Schrenk, chairman commission on forestry.
- Dr. William H. Black, member commission on waterways.
- Mr. T. H. Herring, member commission on waterways.
- Mr. W. K. James, member commission on waterways.
- Mr. S. Waters Fox.

Nebraska—
- Prof. G. E. Condra, chairman conservation commission.
- Mr. P. H. Marlay, member conservation commission.
- Mr. F. D. Wead, member conservation commission.

New Jersey—
- Mr. E. B. Voorhees, chairman conservation commission.
- Mr. Alfred Gaskill, state forester and member conservation commission.
- Dr. Henry B. Kümmel, member conservation commission.
- Mr. Henry J. Sherman, member conservation commission.
- Mr. Morris R. Sherrerd, member conservation commission.

New Mexico—
- Hon. Solomon Luna, chairman conservation commission.
- Hon. H. W. Kelly, member conservation commission.

New York—
- Hon. Raymond A. Pearson, member conservation commission.
- Hon. Henry H. Persons, member conservation commission.
- Hon. Frederick Skene, member conservation commission.
- Hon. Frederick C. Stevens, member conservation commission.

Ohio—
- Mr. Jacob A. Beidler, chairman forestry bureau.

Oregon—
- Hon. Joseph N. Teal, chairman conservation commission.

Pennsylvania—
- Dr. J. T. Rothrock, chairman conservation commission.
- Mr. Powell Evans, member conservation commission.
- Mr. A. B. Farquhar, member conservation commission.
- Col. Wm. S. Harvey, member conservation commission.
- Hon. W. R. Smith, Member of Congress.

Rhode Island—
- Mr. Henry A. Barker, chairman conservation commission.
- Mr. J. Herbert Shedd, member conservation commission.
- Mr. Jesse B. Mowry.

South Carolina—
- Mr. E. J. Watson, chairman conservation committee.
- Prof. Earle Sloan, member conservation committee.

South Dakota—
- Hon. Robert J. Gamble, chairman conservation commission.
- Mr. Eben W. Martin, member conservation commission.

Tennessee—
- Prof. L. C. Glenn.

Utah—
- Hon. O. J. Salisbury, chairman conservation commission.
- Hon. A. W. Ivins, member conservation commission.

Virginia—
- Hon. P. St. Julian Wilson, chairman conservation commission.
- Dr. Thomas L. Watson, member conservation commission.
- Hon. George W. Koiner, member conservation commission.
- Hon. W. E. Bibb, member conservation commission.

Representatives of the States—Continued.

West Virginia—
- Mr. Hu Maxwell, chairman conservation commission.
- Mr. Neil Robinson, member conservation commission.
- Mr. James H. Stewart, member conservation commission.
- Mr. G. W. Atkinson.

Representatives of national organizations:

American Academy of Political and Social Science—
- Prof. Emory R. Johnson, chairman conservation committee.
- Dr. S. M. Lindsay, member conservation committee.

American Association for the Advancement of Science—
- Prof. Wm. F. M. Goss, personal representative of the president.

American Association of Agricultural Colleges and Experiment Stations—
- Mr. J. L. Snyder, president.

American Automobile Association—
- Mr. Powell Evans, personal representative.
- Mr. C. Gordon Neff, member conservation committee.

American Bar Association—
- Mr. John Hinckley, secretary.

American Chemical Society—
- Prof. Marston T. Bogert, president.
- Dr. F. W. Clarke, chief chemist U. S. Geological Survey, and member conservation committee.
- Mr. R. B. Dole, member conservation committee.

American Civic Association—
- Mr. J. Horace McFarland, president.
- Mr. Clinton Rogers Woodruff, secretary.
- Mr. A. B. Farquhar, member conservation committee.

American Electrochemical Society—
- Mr. Edward G. Acheson, president.
- Mr. Edward R. Taylor, chairman conservation committee.

American Federation of Labor—
- Mr. Samuel Gompers, president.
- Mr. James O'Connell, third vice-president.
- Mr. Frank Morrison, secretary.

American Forestry Association—
- Col. Wm. S. Harvey, member board of directors.

American Institute of Architects—
- Mr. Cass Gilbert, president.

American Institute of Electrical Engineers—
- Mr. John H. Finney, member conservation committee.

American Institute of Mining Engineers—
- Mr. John Hays Hammond, president.

American Medical Association—
- Dr. Herbert L. Burrell, president.
- Dr. J. H. Musser, chairman conservation committee.
- Dr. George W. Gay, member conservation committee.

American Mining Congress—
- Judge J. H. Richards, president.
- Mr. E. R. Buckley, first vice-president.
- Mr. J. T. Callbreath, jr., secretary.

American Newspaper Publishers Association—
- Mr. John Norris, chairman conservation committee.

American Railway Association—
- Mr. Arthur Hale, personal representative.

American Railway Engineering and Maintenance of Way Association—
- Mr. Wm. McNab, president.

American Scenic and Historic Preservation Society—
- Mr. Hiram J. Messenger.

American Society of Civil Engineers—
- Mr. Chas. Macdonald, president.

Representatives of national organizations—Continued.

- American Society of Mechanical Engineers—
  - Mr. Calvin W. Rice, secretary.
  - Mr. Luther D. Burlingame, representative conservation committee.
  - Mr. John R. Freeman, member advisory board.
  - Mr. Jesse M. Smith.
- American Society for Testing Materials—
  - Mr. Chas. B. Dudley, president.
- Appalachian National Forest Association—
  - Hon. D. A. Tompkins, president.
  - Mr. John H. Finney, secretary.
- Atlantic Deeper Waterways Association—
  - Hon. J. Hampton Moore, president.
- Business Men's League of America—
  - Mr. James E. Smith, president.
  - Mr. Wm. F. Saunders, secretary.
  - Mr. Clarence H. Howard, member conservation committee.
  - Mr. Geo. W. Simmons, member conservation committee.
- Carriage Builders' National Association—
  - Mr. Geo. H. Babcock, member conservation committee.
  - Mr. W. P. Champney, member conservation committee.
- Conservation League of America—
  - Mr. Walter L. Fisher, president.
  - Mr. John F. Bass.
  - Mr. Lauriston Ward.
- Farmers' National Congress—
  - Hon. B. Cameron, president.
  - Mr. A. C. Fuller, member executive committee.
  - Mr. E. W. Wickey, member executive committee.
- General Federation of Women's Clubs—
  - Mrs. F. W. Gerard, chairman committee on forestry.
  - Mrs. John D. Wilkinson, chairman committee on waterways.
  - Miss Laura D. Gill.
- International Tax Association—
  - Mr. Lawson Purdy, vice-president.
  - Mr. A. C. Pleydell, secretary.
- Interstate Inland Waterway—
  - Mr. C. S. E. Holland, president.
- Interstate Mississippi River Improvement Association—
  - Mr. Charles Scott, president.
- Lakes-to-the-Gulf-Deep Waterway Association—
  - Mr. Wm. K. Kavanaugh, president.
  - Mr. Wm. F. Saunders, secretary.
  - Mr. Lyman E. Cooley, member conservation committee.
  - Hon. X. O. Pindall, member conservation committee.
  - Mr. Charles Scott, member conservation committee.
  - Mr. James E. Smith, member conservation committee.
- Missouri River Improvement Association—
  - Col. Henry T. Clarke, president.
- National Academy of Sciences—
  - Dr. Ira Remsen, president.
  - Prof. William Bullock Clark, chairman conservation committee.
  - Prof. E. G. Conklin, member conservation committee.
- National Association of Agricultural Implements and Vehicle Manufacturers—
  - Mr. Newell Sanders, chairman conservation committee.
- National Association of Audubon Societies—
  - Mr. T. Gilbert Pearson, member conservation committee.
- National Association of Cotton Manufacturers—
  - Mr. C. J. Woodbury, secretary.
- National Association of Manufacturers—
  - Mr. James W. Van Cleave, president.
- National Board of Fire Underwriters—
  - Mr. J. Montgomery Hare, president.

Representatives of national organizations—Continued.

- National Board of Trade—
  - Mr. Frank D. La Lanne, president.
- National Business League of America—
  - Mr. La Verne W. Noyes, president and member conservation commission.
  - Mr. Victor Falkenau, chairman conservation commission.
  - Mr. A. B. Farquhar, member conservation commission.
- National Civic Federation—
  - Mr. John Mitchell, chairman trade agreement department.
- National Council of Commerce—
  - Mr. George L. McCarthy, member conservation committee.
  - Mr. H. E. Miles, member conservation committee.
  - Mr. Frank B. Wiborg, member conservation committee.
- National Drainage Association—
  - Hon. Napoleon B. Broward, president.
- National Editorial Association—
  - Mr. Chester Harrison, member conservation committee.
- National Electric Light Association—
  - Mr. Dudley Farrand, chairman conservation committee.
- National Forest Conservation League—
  - Hon. Samuel R. Van Sant, president.
  - Mr. Theodore Knappen, secretary.
  - Mr. W. S. Dwinnell.
- National Grange—
  - Mr. H. J. Patterson.
- National Hay Association—
  - Mr. Maurice Neizer, president.
- National Hickory Association—
  - Mr. H. D. Hartley, secretary and member conservation committee.
- National Irrigation Congress—
  - Mr. George E. Barstow, president.
- National Lumber Manufacturers' Association—
  - Mr. George K. Smith, secretary.
- National Municipal League—
  - Mr. Clinton Rogers Woodruff, secretary.
- National Slack Cooperage Manufacturers' Association—
  - Mr. C. M. Van Aiken, president.
- National Tax Association—
  - Mr. A. C. Pleydell.
  - Mr. Lawson Purdy.
- Trans-Mississippi Commercial Congress—
  - Mr. Thomas F. Walsh, president.
  - Mr. J. T. Callbreath, jr.
  - Mr. J. B. Case.
  - Mr. F. W. Fleming.
  - Mr. I. T. Pryor.
- Upper Mississippi River Improvement Association—
  - Mr. Thomas Wilkinson, president.
- Woman's National Rivers and Harbors Congress—
  - Mrs. Frances Shuttleworth, corresponding secretary.

Bureau chiefs and experts:

- Geological Survey—
  - Dr. George Otis Smith, Director.
  - Mr. Henry Gannett, geographer national conservation commission.
  - Mr. Robert Follansbee.
  - Mr. R. B. Dole.
  - Dr. D. T. Day.
  - Mr. M. R. Campbell.
  - Dr. C. W. Hayes.
  - Mr. M. O. Leighton.

Bureau chiefs and experts—Continued.

Geological Survey—Continued.
- Mr. W. C. Mendenhall.
- Mr. E. W. Parker.
- Mr. F. B. Van Horn.
- Dr. Bailey Willis.
- Mr. H. M. Wilson.

Forest Service—
- Mr. Wm. T. Cox.
- Mr. Wm. L. Hall.
- Mr. R. S. Kellogg.
- Mr. A. C. Shaw.
- Mr. Philip P. Wells.
- Mr. E. A. Ziegler.

General Land Office—
- Hon. Fred Dennett, Commissioner.
- Mr. Francis W. Clements, first assistant attorney.
- Mr. E. C. Finney.

Bureau of Statistics, Department of Commerce and Labor—
- Dr. O. P. Austin, Chief.

Bureau of Entomology—
- Dr. L. O. Howard, Chief.
- Mr. C. L. Marlatt.
- Dr. A. D. Hopkins.

Weather Bureau—
- Prof. Willis L. Moore, Chief.
- Prof. Harry C. Frankenfield.

Reclamation Service—
- Mr. Morris Bien.

Indian Office—
- Mr R. G. Valentine.

Bureau of Plant Industry—
- Dr. B. T. Galloway, Chief.

Bureau of Corporations—
- Mr. W. B. Hunter.

Biological Survey—
- Dr. C. Hart Merriam, Chief.

Bureau of Statistics, Department of Agriculture—
- Hon. Victor H. Olmsted, Chief Statistician.

Bureau of Fisheries—
- Mr. Hugh M. Smith.

Office of Experiment Stations—
- Dr. A. C. True, Director.

Bureau of Chemistry—
- Dr. H. W. Wiley, Chief.

Bureau of Soils—
- Dr. Milton Whitney, Chief.

Delegates at Large:
- Mr. Victor C. Alderson, Colorado.
- Mr. Geo. N. Babb, New York.
- Mr. R. Dan Benson, Pennsylvania.
- Mr. Chas. W. Bernhardt, Georgia.
- Mr. Nathan D. Bill, Massachusetts.
- Mr. George Black, Washington.
- Mr. W. F. Black, Alabama.
- Mr. L. W. Brown, Virginia.
- Mr. W. P. Brown, Washington.
- Mr. A. W. Butler, Maine.
- Mr. Joseph L. Cahall, Delaware.
- Mr. W. M. Cameron, Tennessee.
- Mr. Thomas W. Carmichael.
- Mr. S. H. Chappell, Georgia.
- Mr. R. F. Clerc, Louisiana.

Delegates at large—Continued.

Mr. Geo. Ward Cook, Massachusetts.
Mr. S. A. Cosulich, Louisiana.
Mr. S. H. Cowan, Texas.
Mr. John Craft, Alabama.
Mr. Thomas F. Cunningham, Louisiana.
Mr. A. W. Damon, Massachusetts.
Mr. J. A. Delfeker, Wyoming.
Mr. Gould Dietz, Omaha.
Mr. Theodore Dwight, New York.
Mr. C. H. Ellis, Louisiana.
Mr. B. F. Eshleman, Wyoming.
Mr. John W. Faxon, Tennessee.
Mr. Chas. D. Gates, Kentucky.
Dr. Edward Everett Hale, Washington, D. C.
Mr. Henry R. Hayes, Massachusetts.
Mr. W. S. Holman, Texas.
Mr. E. S. Johnson, Georgia.
Mr. P. G. Johnston, Idaho.
Mr. Charles P. Johnston, Louisiana.
Mr. H. S. Keathoper, Alabama.
Mr. M. N. Kline, Pennsylvania.
Mr. Victor M. Lefebere, Louisiana.
Mr. Sidney F. Lewis, Louisiana.
Mr. H. H. Little, Virginia.
Mr. Wm. McCarroll, New York.
Mr. J. T. McClellan.
Mr. V. Manvin, Louisiana.
Mr. Josiah Marvel, Delaware.
Mr. H. J. Messenger, Connecticut.
Mr. Roy Miller, Texas.
Mr. R. A. Mitchell, Alabama.
Mr. S. F. Mosle, Texas.
Mr. W. J. Nebb, Georgia.
Mrs. Mary M. North, Maryland.
Mrs. Lina Simpson Poffenboyer, West Virginia.
Mr. Wm. F. Prouty, Alabama.
Mr. J. T. Pryor, Texas.
Mr. C. E. Rafferty, Washington, D. C.
Hon. F. A. Richards, Massachusetts.
Mr. Franklin C. Robinson, Maine.
Mr. G. A. Rogers, Kansas.
Mr. W. B. Royster, Tennessee.
Mr. F. D. Ryan, Washington.
Mr. C. G. Smith, New York.
Mr. H. C. Smith, Louisiana.
Mr. Edwin A. Start, Massachusetts.
Mr. Charles J. Swift, Georgia.
Mr. E. C. Taleny, Mississippi.
Mr. S. Taliaferrio, Texas.
Mr. M. B. Trezevant, Louisiana.
Mr. Louis Ed. Vanoft, Louisiana.
Mr. J. S. Warren, Tennessee.
Mr. J. H. Woods, Massachusetts.
and

The National Conservation Commission.

GIFFORD PINCHOT,
Chairman of the Joint Conference.

THOMAS R. SHIPP,
Secretary of the Joint Conference.

STATEMENTS BY THE SECRETARIES.

SECTION OF WATERS (Inland Waterways Commission).
SECTION OF FORESTS.
SECTION OF LANDS.
SECTION OF MINERALS.

WATER RESOURCES.

WHAT WE HAVE.

The sole source of our fresh water is rainfall (including snow). From this source our running, standing, and ground waters are derived. The habitability of the country depends on these waters.

Through the observations and measurements of the Weather Bureau at some 4,000 stations our rainfall is known more accurately than that of any other equal area on the globe. The records furnished by Chief Willis L. Moore, interpreted and reduced by Henry Gannett, show a yearly mean of approximately 30 inches. The quantity falling on the land averages about 200,000,000,000,000 cubic feet per year; including the rainfall on water areas, it is 215,000,000,000,000 cubic feet.[a] The volume is ten Mississippi rivers.

The yearly rainfall on the more humid two-fifths of the country east of the ninety-fifth meridian (or what may be called the State Divide forming the eastern boundary of the Median States—North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas) is nearly 48 inches; the quantity about 140,000,000,000,000 cubic feet. On the semiarid fifth of our area in these Median States (or between the ninety-fifth and one hundred and third meridians) the rainfall averages 30 inches and aggregates over 40,000,000,000,000 cubic feet. The rainfall on the western two-fifths of the country, including our arid lands, averages about 12 inches, or some 35,000,000,000,000 cubic feet.

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[a] The quantitative view of water, except in smaller measures, is so new to thought that familiar units are lacking. Municipal water supply is generally expressed in gallons, irrigation water in acre-feet, stream flow in second-feet (or more accurately seconds-feet), and water for certain uses in the variable and indefinite miner's inch. There is urgent need of a unit applicable to the quantities commonly used for water supply, irrigation, and various other purposes. Moderate familiarity with the metric system would render convenient as such a unit the stere (equivalent to the kiloliter or cubic meter, the virtual basis of the metric system for capacity or tridimensional measure), which roughly approximates—like the liter the quart—the cubic yard in quantity and the ton in weight of water, while the kilostere approximates 1,000 tons and an acre-foot. The kilostere is especially convenient in discussing the water supply of the United States in that it permits expression of the leading values in round numbers not too large for ready comprehension—the mean rainfall totaling 6,000,000,000 kilosteres, and its main derivative fractions being expressible in sixths of this total. A kilostere of water is equivalent to a cube of 32.8 feet.

A few of the equivalents involved in the use of the stere for the measurement of water (reckoned at maximum density) follow:

1 liter=1.057 quarts; 0.264 gallon; 61.023 cubic inches; 2.205 pounds.
1 kiloliter=1,000 liters; 1 stere; 1 cubic meter; 264.17 gallons; 35.314 cubic feet; 2,204.62 pounds.
1 kilostere=1,000 kiloliters; 264,180 gallons; 35,314.45 cubic feet; 0.8107 acre-foot; 1,102.31 tons.
1 gallon=3.785 liters; 231 cubic inches; 0.1336 cubic foot; 8.34 pounds.
1 cubic foot=28.317 liters; 7.48 gallons; 62.43 pounds.
1 cubic mile=147,197,952,000 cubic feet; 4,168.208 kilosteres; 3,397,200 acre-feet; 4,594,784,072 tons.
1 ton=2,000 pounds; 32.04 cubic feet; 907.19 liters; 239.65 gallons.
1 pound=27.68 cubic inches; 0.4536 liter; 0.12 gallon.
215,000,000,000,000 cubic feet=6,088,236,690 kilosteres; 4,935,720,845 acre-feet; 1,460.6 cubic miles.
215,000,000,000,000 cubic feet±6,000,000,000 kilosteres; 5,000,000,000 acre-feet; 1,500 cubic miles.

Of the total rainfall, over half is evaporated; about a third flows into the sea; the remaining sixth is either consumed or absorbed. These portions, which may be called, respectively, the fly-off, the run-off, and the cut-off, are partly interchangeable. About a third of the run-off, or a tenth of the entire rainfall, passes through the Mississippi. The run-off is increasing with cultivation and deforestation.

The 110,000,000,000,000 cubic feet of fly-off influences climate, and thus affects agriculture and other industries. Except in moderate degree through management of the land surface, it is beyond artificial control.

The 70,000,000,000,000 cubic feet of run-off is available for water supply, irrigation, navigation, and power. It is controlled in small part, and may be wholly controlled by proper means.

The remainder of the rainfall (or cut-off) is either consumed in plant growth and other chemical combinations, or else permeates the deeper strata and passes subterraneously into the sea. It is partly controlled, chiefly through farming and forestry; and the control may be much increased.

WHAT WE USE AND WASTE.

Of the 110,000,000,000,000 cubic feet of water annually evaporated, a reasonable use is made through the settlement and general industrial development of the country. It is adapted to largely increased population and industries.

Of the 70,000,000,000,000 cubic feet annually flowing into the sea, little more than 100,000,000,000 cubic feet, or one-seventh of 1 per cent, is taken from rivers and lakes and protected catchment areas for municipal and community supply and related purposes; less than 2 per cent (or some 10 per cent of that in the arid and semiarid regions) is used for irrigation; perhaps 5 per cent may be reckoned as in small use for navigation; and less than 5 per cent is utilized for power. It is estimated that 85 per cent to 95 per cent of the volume is wasted in freshets or destructive floods.

It is reckoned by Chief Leighton of the hydrographic branch of the Geological Survey that for municipal and community water supply there are protected catchment areas aggregating over 1,000,000 acres, and that fully $250,000,000 are invested in waterworks with nearly as much more in the appurtenant catchment areas and other lands. The population so supplied approaches 10,000,000; the annual consumption is about 37,500,000,000 cubic feet, or one-twentieth of 1 per cent of our run-off. The better managed systems protect the catchment areas by forests or grass; the water is completely controlled, the storm product is stored, and there is little waste save through overlavish use after the impounded flow enters the mains.

For irrigation it is estimated by Director Newell of the Reclamation Service that there are $200,000,000 in vested in dams, ditches, reservoirs, and other works for the partial control of the waters (in addition to the value of the land, which is virtually fixed by the availability of the water); and that 1,500,000,000,000 cubic feet, i. e., three-quarters of 1 per cent of our total rainfall, or 2 per cent of that on the western two-fifths of our area, are annually diverted to irrigable lands aggregating some 13,000,000 acres. Except in some cases through forestry, there is little effort to control the catchment areas, and few reservoirs are large enough to hold the storm waters; so that the waste in public and private projects exceeds 60 per cent, while less than 25 per cent of the water actually available for irrigation of the arid lands is restrained and diverted.

There are in mainland United States 287 streams navigated for an aggregate of 26,226 miles,[a] and about an equal additional mileage might be made navigable by waterway improvements. There are also 45 canals with a mileage of 2,189, besides numerous abandoned canals.[b] On lake and sound routes there is large traffic, but the navigation of rivers and canals is too small for definite record. Several hundred million dollars have been expended on special projects, yet, "in spite of large appropriations for their improvement, our rivers are less serviceable for interstate commerce to-day than they were half a century ago."[c] The cost of water carriage averaging about one-fourth that of rail carriage, and our railway freightage during 1906 reaching 217,000,000,000 ton-miles at an average rate of 0.77 cent, the shipping of one-fifth of our freight by water would have saved over $250,000,000 to our producers and consumers. Except through forestry in recent years, together with a few reservoirs and canal locks and movable dams, there has been little effort to control headwaters or catchment areas in the interests of navigation; and none of our rivers are navigated to more than a small fraction even of their effective low-water capacity.

The theoretical power of the streams is reckoned by Leighton at 230,000,000 horsepower. The amount now in use is computed by the Census Office at 5,350,000 horsepower, and the amount running over government dams and not used is estimated by the Chief of Engineers at about 1,400,000 horsepower. The amount now available at a cost comparable with that of steam installation is estimated by the hydrographic branch of the Geological Survey at 37,000,000 horsepower, and the amount prospectively available at 75,000,000 to 150,000,000 horsepower. The 37,000,000 horsepower to-day available exceeds our entire mechanical power now in use, and would operate every mill, drive every spindle, propel every train and boat, and light every city, town, and village in the country. The nominal value is $20 per horsepower year; the price ranges up to $100 or $150. While the utilization of water power ranks among our most recent and most rapid industrial developments, little effort has been made to control catchment areas or storm waters in any large way for power development, though most plants effect local control through reservoirs and structures. Nearly all of the freshet and flood water runs to waste, and the low waters which limit the efficiency of power plants are increasing in frequency and duration with the increasing flood run-off.

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[a] Preliminary Report of the Inland Waterways Commission, 1908: Herbert Knox Smith on "Navigable Streams of the United States," p. 35.

[b] Ibid.: Herbert Knox Smith on "Canals in the United States," p. 192.

[c] Ibid.: "Message of the President," p. vi.

The practical utility of streams for both navigation and power is measured by the effective low-water stage; the volume carried when the streams rise above this stage (75 to 90 per cent of the run-off) is not only wasted but does serious damage. The direct yearly damage by floods since 1900, as computed by Leighton, has increased steadily from $45,000,000 to more than $238,000,000; the indirect loss through depreciation of property is probably greater; while the largest loss is that arising in impeded traffic through navigation and terminal transfers.

The freshets are attended by destructive soil erosion. The soil matter annually carried into lower rivers and harbors or into the sea has recently been reckoned by Dole and Stabler at 783,000,000 tons. Its removal seriously reduces the productivity of upland farms, and increases channel cutting and bar building in the rivers. It is estimated that soil erosion reduces farm production 10 to 20 per cent; that the annual loss to the farms alone is $500,000,000; and that large losses follow the fouling of the waters and the diminished navigability of the streams.

Through imperfect control of the running waters, lowlands are temporarily or permanently flooded. It is estimated that there are in mainland United States 75,000,000 to 80,000,000 acres of overflow and swamp lands requiring drainage; that by systematic operations these might be drained and the water made available at moderate expense, and that they would then be worth two or three times the present value and cost of drainage, and would furnish homes for 10,000,000 inhabitants.

A part of the run-off lodges temporarily in lakes and ponds. It is estimated that the quantity of fresh water so stored (including the American portion of the Great Lakes) is about 600,000,000,000,000 cubic feet, equivalent to three years' rainfall or nine years' run-off. Over the water surface evaporation is rapid, and the influence of the lakes on climate is correspondingly large; and the natural reservoirs yield a water supply ordinarily requiring no control of catchment area. Some 6,000,000 of our people draw their water supply from lakes. All the larger and deeper lakes are navigated; they serve the chief part of our inland commerce by water.

A large part of that half of the annual rainfall not evaporated lodges temporarily in the soil and earth as ground water. According to texture, fire-dry rocks contain 1 to 3 per cent, air-dry rocks 5 to 25 per cent, and saturated rocks and earths 10 to 40 per cent of water, while the optimum moisture for plant growth in top soil ranges from 4 to 20 per cent; and it is estimated that the ground water to the depth of 100 feet (in which it is available for hand pumps and capillarity and deep-rooted trees) averages 5 per cent over 1,000,000 square miles, 20 per cent over another third of the country, and 25 per cent over the remaining third, a mean of 16⅔ per cent. This ground water forms a subsurface reservoir of over 1,400,000,000,000,000 cubic feet, equivalent to seven years' rainfall or twenty years' run-off. It is the essential basis of agriculture and most other industries, and the chief natural resource of the country; it sustains forests and all other crops, and supplies the perennial streams and springs and wells used by four-fifths of our population and nearly all our domestic animals. Its quantity is diminished by the increased run-off due to deforestation and injudicious farming. Throughout the upland portions of eastern United States the average water table has been lowered 10 to 40 feet, so that fully three-fourths of the springs and shallower wells have failed and many brooks have run dry, while the risk of crop loss by drought has proportionately increased. Although the available ground water is subject to control by such treatment of soil and plant growth as to prevent freshets, little effort has been made to retain it or increase its volume, and it is probable that fully 10 per cent of this rich resource has been allowed to drain away since settlement began. The water of the deeper rocks (below 100 feet) supplies artesian and other deep wells, thermal and mineral waters, and large springs. It can be controlled in part, chiefly through the subsurface reservoir, and the supply may be much better utilized.

Of the 35,000,000,000,000 cubic feet of cut-off, the chief share is utilized in natural processes or by agriculture and related industries. On an average, plant tissue in annual growths is three-fourths and in perennial growths three-eighths water; of human and stock food over 80 per cent is water, and in animal tissue the ratio is about the same; and water is the chief vehicle for the transmission of enteric and many other diseases. Since water is the medium for organic circulation, the plants and animals of the country yearly require an amount many times exceeding their aggregate volume. The average man of 150 pounds ingests over a ton (32 cubic feet, or 13 times his volume) of water each year, and an average bushel of corn requires over 700 cubic feet, or 22 tons, of water in the making, of which the larger part is evaporated and added to the fly-off. Even in the more humid sections of the country the productivity of the soil and the possible human population would be much larger if the rainfall were greater, leaving a wider margin for organic and other chemical uses. Except through agriculture and forestry, little general effort is made to control the annual cut-off, although some farmers in arid regions claim to double or triple the crop from given soil by supplying water just when needed and withholding it when not required.

WHERE WE STAND.

Our stock of water is like other resources in that its quantity is limited. It differs from such mineral resources as coal and iron, which once used, are gone forever, in that the supply is perpetual; and it differs from such resources as soils and forests, which are capable of renewal or increase (provided the supply of water suffices), in that its quantity can not be augmented. It differs also in that its relative quantity is too small to permit full development of other resources and of the population and industries depending on them. Like all other resources, it may be better utilized. It must be better utilized in order to derive full benefit from lands and forests and mines.

Although our rainfall of 215,000,000,000,000 cubic feet is 2,500,000 cubic feet per capita for a population of 86,000,000 (or 250,000 cubic feet, allowing for the 90 per cent waste), our growth in population and industries is seriously retarded by dearth and misuse of water. Fully a third of our territory (1,000,000 square miles, the area of Great Britain, Germany, France, Spain, Portugal, Italy, Austria, and Denmark combined) remains practically unoccupied and nearly unproductive by reason of aridity; while the public lands sufficiently humid for agricultural settlement are taken, the cost of transportation is limiting production, and our citizens are emigrating in thousands to other countries. With half our land area and the same water, our capacity for population and industries would be great as now; with twice our water equably distributed over our present land, our capacity would be more than doubled.

Hitherto water has seldom been regarded as a resource to be exploited and conserved; it has been viewed vaguely as a prime necessity, yet merely as a natural incident or providential blessing. In its assumed plenitude the idea of quantity has seldom arisen, though the waste is least in those arid regions in which customs are better adjusted to the values and interrelations of water. Under the English common law, prevailing in eastern United States, the water is held appurtenant to the land; under the Code Napoleon, prevailing in Louisiana, it virtually appertains to the community; under the Spanish-Roman law, prevailing in western United States, water is subject to prior appropriation and beneficial use, and hence appertains primarily to the individual or family, while the land is essentially appurtenant to the water traversing it.

Not being deemed a resource when our fundamental law was framed, the waters were in no wise granted by the people, except as employed in commerce under federal authority; and since their value has arisen through the natural growth and orderly development of our population and industries, they seem in equity to belong to the people collectively. When required by municipalities or communities, water is restrained and used as a matter of course, and the cost of the appurtenant land and works for its control is ordinarily borne by taxation offset by water rates, i. e., the water is appropriated and exploited, and then conveyed or sold as a commodity in the interests of the population supplied; and in all cases the investment (generally at first thought burdensome) proves either highly remunerative or inconsiderable in proportion to the benefits. When streams are controlled by individuals for power under federal grants, the power becomes a taxable commodity used, rented, or sold, certain rights being retained by the Federal Government in the interest of the people; and power developed by the nation in works connected with commerce is used, rented, or sold. Some States recognize a residuary right of the people in the natural waters, or in the headwaters of streams used for water supply or navigation, and this recognition seems to be extending over the country; but the usage of the different sections is not uniform, the exercise of the right of the people generally varying with the aridity of the land or the density of the population.

Since most navigable streams bound or traverse different Commonwealths, while the waters forming them are unstable and essentially interstate, the States generally have refrained from waterway improvement, save through a few canals and drainage projects; and since the headwaters on which the navigability depends are commonly intrastate, the Federal Government has refrained from assuming more than a partial and ineffective control of the navigable waters. Thus a half-hearted and irresponsible or repressive policy has grown up; navigation has been neglected and allowed to decline; both control of the running waters and recognition of their value have been delayed, and private monopoly has been permitted to invade to their detriment the source waters on which the rivers depend.

Some of our navigable and other waters are international, and questions of both civil jurisdiction and control or use of the flow have been or are being composed by treaty or convention sanctioned by laws of the nations in interest. In the Great Lakes and Columbia regions each second-foot of flow corresponds to about a square mile of land surface drained—i. e., an outtake of 10,000 second-feet involves relations equivalent to titular questions affecting 10,000 square miles of territory; and in the Rio Grande and Rio Colorado regions each second-foot of flow is equivalent to 20 or 25 square miles of territory.

It is now recognized by leading statesmen and experts that navigation is interdependent with other uses of the streams;[a] that each stream is essentially a unit from its source to the sea;[b] that the power of the Federal Government to improve navigable streams extends above the limit of navigability;[c] and that the benefits of a comprehensive system of waterway improvement will extend to all the people in the several sections and States of the country.[d]

It is also recognized, through the unanimous declaration of the governors of the States and Territories adopted in conference with the leading jurists, statesmen, and experts of the country, that in the use of the natural resources the independent States are interdependent, and bound together by ties of mutual benefits, responsibilities, and duties.[e]

It has recently been declared by a majority of our leading statesmen that it is an imperative duty to enter upon a systematic improvement, on a large and comprehensive plan, just to all portions of the country, of the waterways and harbors and Great Lakes whose natural adaptability to the increasing traffic of the land is one of the greatest gifts of a benign Providence; while a strong minority of the nation's statesmen indorsed the movement for control of the waterways more specifically and in equally emphatic terms.

Within recent months it has been recognized and demanded by a majority of the people, through many thousand delegates from all of the States assembled in conventions in different sections of the country, that the waterways should and must be improved promptly and effectively as a means of maintaining national prosperity, the cost to be borne either by federal appropriations or by the issue of bonds.

WHAT WE NEED TO DO

The first requisite for waterway improvement is control of the waters in such manner as to reduce floods and regulate the regimen of the navigable rivers; the second is development of terminals and connections in such manner as to regulate commerce.

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[a] Preliminary Report of the Inland Waterways Commission, 1908: "Findings," p. 22.

[b] Ibid.: "Message of the President," p. 4.

[c] United States v. Rio Grande Irrigation Company (174 U. S., p. 690 et seq; also report of the Committee on the Judiciary on "Power of the Federal Government to acquire lands for national forest purposes" (60th Cong., 1st sess., H. R. Rep. 1514), p. 20.

[d] Preliminary report of the Inland Waterways Commission, 1908: "Findings," p. 24.

[e] Proceedings of the Conference of Governors, 1908, p. 193.

Most of the headwaters, especially in mountainous regions, may be so controlled by forestation as to diminish floods and ameliorate low waters, and at the same time clarify streams required for water supply and augment the subsurface reservoir of ground water. The effect of forest cover, with the attendant mulch, is to diffuse the rainfall and convert it into ground water, thereby reducing the surface run-off and holding the water back for use in plant growth or in seepage run-off through clear springs and brooks serving to maintain the rivers during dry periods, while the evaporation from the plants serves to increase the rainfall. Under proper management these benefits may be made self-sustaining through increased production.

Most lowland headwaters are on agricultural land, and are subject to control by judicious farming. Since no upland farm receives sufficient rainfall for the highest productivity, every acre should be made to utilize all the water reaching it. This may be effected by deep plowing and proper selection of crops on level land, by contour cultivation and terracing on rolling land, by dust-mulching on arid land, and by other devices of scientific farming. Thereby storm freshets may be cut off, the reservoir of ground water augmented, the springs and wells maintained, and the streams clarified and kept up during dry periods. The devices should be made not only self-supporting, but a source of increased production and profit.

About commercial centers and in populous districts, the paramount use of water is for domestic and manufacturing purposes; and the requisite supply should continue to be appropriated with the appurtenant lands and controlled under consistent State laws and federal regulations in the direct interest of the people. The catchment areas should be protected by proper covers of forest, grass, or other crops yielding reasonable returns, in such manner as to prevent both floods and soil wash with consequent pollution of the reservoirs and menace to life. When supplies are taken from lakes or the ground-water reservoir, both the maintenance of the public health and other uses of the waters (including navigation) should be duly weighed under the principle of the greatest good to the greatest number for the longest time. Wise administration demands that the water-supply projects be made so nearly as possible self-supporting through collateral benefits in order that potable water, as a prime necessary of life, may be placed within reach of all.

Refuse from household, farm, factory, mine, and city should be prevented from polluting streams, or extending needlessly into the ground water or contaminating the air. In rural households and communities refuse should be so treated as to yield high-grade fertilizer; urban sewage should be converted and utilized as a source of municipal revenue; and mine refuse should be treated as a by-product.

In arid and semiarid lands irrigation is (next to water supply) paramount, and all the water should be made available for the population dependent on each catchment basin. To this end the headwaters should be so controlled as to regulate the flow, the reservoirs should be large enough to store the surplus and prevent waste, and navigation should be limited to reservoirs and canals. Each irrigation project should be self-supporting; and any surplus or return water should remain in the natural channels available for other uses pending complete consumption in irrigation.

The navigable streams, partly controlled through their headwaters, should be further regulated by lock dams, movable dams, reservoirs, and other engineering devices found expedient in particular cases. They should be administered under federal regulations in the interest of the people, either independently or in cooperation with States, municipalities, communities, corporations, or individuals, as may be found expedient in particular cases. The projects should comprise such terminals and sites and such regulation thereof as may be essential to commerce. Drainage projects should be adapted, so far as practicable, to aiding in the control of the waters for navigation and related purposes.

When necessary, provision should be made for levees, jetties, hurdles, wing dams, revetment, mattressing, dredging, and other means of temporary and supplementary control of the waters and channels; and both the works and their sites should be acquired and protected under federal or State authority.

When consistent with other uses of the waters, fish should be propagated and protected in streams and lakes, and necessary fishways should be provided in connection with dams and other works; and State and federal laws relating to fish and fisheries in inland and coast waters should be unified.

In the design and construction of works connected with water supply, irrigation, navigation, or the control of water for other purposes, consideration should be given to the power developed thereby and to the equity of the people in this value of the waters; and all benefits derived from power in connection with works installed at the public cost should be applied to the public welfare through protection against loss or diminution of the cost of additional works, or in other proper ways.

In considering the benefits to be derived from the 215,000,000,000,000 cubic feet of water annually received, the paramount use should be that of water supply; next should follow navigation in humid regions and irrigation in arid regions. The utilization of power from the navigable and source streams should be kept subordinate to the primary and secondary uses of the waters, though, other things equal, power development should be encouraged, not only to reduce the drain on other resources, but because properly designed reservoirs and power plants retard the run-off and so aid in the control of the streams for navigation and other uses.

The broad plan already framed by statesmen and experts and approved by the Executive should be put in effect. It provides for a system of waterway improvement extending to all of the uses of the waters and benefits to be derived from their control, including the clarification of the water and the abatement of floods for the benefit of navigation, the extension of irrigation, the development and application of power, the prevention of soil wash, the purification of streams for water supply, and the drainage and utilization of the waters from swamp and overflow lands; and that the work shall be carried on by existing agencies in the federal departments under an administrative commission or board to be appointed by the President, acting in cooperation with States, municipalities, communities, corporations, and individuals.[a]

The improvements should conform to the plan already outlined.[b] In the Atlantic-interior system there should be a deep waterway from Gulf of Mexico to the Great Lakes and a deep and continuous Atlantic inner passage from New England to Florida, the present plan for improving the Ohio should be carried out promptly and should be perfected by any forestation and reservoirs required to control the headwaters, the upper Mississippi and the Missouri should be improved and canalized, the lower Mississippi should be connected with the Rio Grande and with the waters of Florida by inner passages, the navigable rivers flowing into Gulf of Mexico and Atlantic Ocean should be improved, and all appropriate links in the system should be adapted to vessels of standard depth and should be connected with one another and with the Great Lakes by canals of standard dimensions. In the Columbia-Puget system the rivers should be improved and requisite connecting canals should be constructed; and in the California system Sacramento, San Joaquin, and Feather rivers should be so improved as to open the country to interstate and foreign commerce.

To promote and perfect the plan, scientific investigations, surveys, and measurements should be continued and extended, especially the more accurate determination of rainfall and evaporation, the investigation and measurement of ground water, the gauging of streams and determination of sediment, and topographic surveys of catchment areas and sites available for control of the waters for navigation and related purposes.

It has been roughly estimated that the inland waterways of the country could be improved in ten years at a cost of $50,000,000 annually in such manner as to promote interstate commerce and at the same time greatly reduce the waste and extend the use of the waters. If done at the cost of the people, the burden would be 62½ cents per capita per year, or $6.25 in all, for a population of 80,000,000. This burden should be assumed without delay either by appropriations or by the issue of bonds in small denominations bearing low interest, adapted to distributing both the burden and benefits among the people.

It is roughly estimated that the direct benefits would comprise an annual saving in transportation of $250,000,000; an annual saving in flood damage of $150,000,000; an average annual saving in forest fires of at least $25,000,000; an annual benefit through cheapened power of fully $75,000,000; and an annual saving in soil erosion (or corresponding benefit through increased farm production) of $500,000,000—a total of $1,000,000,000, or $12.50 per capita annually, i. e., twenty times the cost. In addition, large benefits would result from extended irrigation, from the drainage and settlement of swamp and overflow lands, and from purified and cheapened water supply with consequent diminution of disease and saving of human life.

Various indirect benefits would arise through the interrelations among the natural resources. For example, the development of water traffic in lieu of rail carriage would reduce the constantly increasing consumption of ties and mine timbers, now a heavy drain on our forests; it would reduce the consumption of iron, since water vehicles require but a quarter to a third of the metal required by rail vehicles of like capacity; and it would correspondingly reduce the consumption of coal for both propulsion and smelting. At the same time the reduced use of ties and mine timbers would save the forests and so aid in protecting the headwaters on which the navigable streams depend for both supply and regimen.

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[a] Preliminary Report of the Inland Waterways Commission, 1908: "Recommendations," pp. 25–27.

[b] Ibid.: "Inquiries in Progress," p. 29.

With a view to promoting interstate commerce, the Federal Government has aided railways by subsidies and grants to the extent of many hundred million dollars, thereby contributing materially to the 228,000 miles of railways and collateral property aggregating about one-seventh of our national wealth and earning nearly $2,500,000,000 annually; yet although our railway freightage runs only about three-quarters of a cent per ton-mile (or half that of Europe), our distances are so great that many commodities can not be moved with profit to and from our ports, and our export of foodstuffs have declined to the disturbance of our foreign commerce. Our farm and forest products exceed $8,000,000,000, our mineral products are $2,000,000,000, and our products of manufacture are fully $15,000,000,000 annually, or a gross nominal output (with considerable duplication) of $25,000,000,000. Of this aggregate, much is not moved by rail, and much more is moved short distances only; yet we paid for railway freightage alone in 1906 no less than $1,659,925,643. Reckoning the total cost of domestic traffic by rail and water and wagon, together with freightage on imports, it is probable that an average American family pays for transportation of food and clothing nearly or quite one-third of their actual cost, i. e., our consumers pay too much and our producers get too little for the necessaries of life. This condition would be relieved, while the railway business would be promoted rather than injured, by the development of water transportation on an adequate scale. The promotion of interstate commerce by railway aid was wise and beneficent in its time; but it is now time to supplement this agency of commerce by others better adapted to our multiplied population and enormously increased production.

It is estimated that the income derived from power developed by works for the improvement of navigation, if utilized at current market rates in cooperation with States and citizens, would alone compensate the entire cost of maintenance and continued development after the initial expenditure of $500,000,000 as a working capital. In any event the first cost should be deemed an investment in the interest of the people, certain to yield large returns in public welfare and national growth.

Whether or not the initial investment be so made as to yield pecuniary returns, the just and reasonable demand of a majority of the people for the improvement of their waterways should be met, and that the more promptly by reason of seventy years of repression.

W J McGee,
Secretary, Section of Waters.

FORESTS.

WHAT FORESTS DO.

Our industries which subsist wholly or mainly upon wood pay the wages of more than 1,500,000 men and women.

Forests not only grow timber, but they hold the soil and they conserve the streams. They abate the wind and give protection from excessive heat or cold. Woodlands make for the fiber, health, and happiness of each citizen and of the nation.

The fish which live in forest waters furnish each year $21,000,000 worth of food, and not less than half as much is furnished by the game which could not exist without the forest.

The industries which use wood wholly or mainly in manufacture represent an investment of over $2,250,000,000 and yield each year a product worth nearly $3,000,000,000.

Forests conserve streams by regulating their flow. Our knowledge of the effect of forests upon the quantity of water carried by streams is not yet complete. Our knowledge of the effect of forests upon the regularity of stream flow has an adequate basis of observation and record.

We do not possess complete scientific proof that forests increase rain, but known laws governing rainfall and the known physical effects of forests lead straight to that conclusion. A part of the falling rain or snow is checked by the tree tops and returned to the air by evaporation. But this evaporation is wholly or nearly compensated for by the smaller evaporation from the soil under forest cover than from the soil in the open. The forest soil gives up water to the air more slowly than either brush land, meadow land, or cultivated fields.

Both observation and record show fully that forests powerfully affect the manner in which water reaches streams and passes down them. The forest floor is a blanket, and like a blanket it will hold more water than will the harder and relatively less porous soil of the open. A saturated forest soil will hold more than half its dry weight in water, or over 6 inches of water for every foot of soil. This, as well as the breaking up of forest soil by the roots of trees and undergrowth, makes it more effective than any other cover for the intake of water into that vast underground reservoir from which all streams and springs are fed.

When the forest is cleared from a mountain watershed the blanket formed by the decaying leaves, branches, and fallen trees is burned up, dried by the sun, or carried off by wind and water. This is inevitably followed by increase in the frequency and duration of floods. This fact is known to every man who has had an opportunity to observe it. To those who have not had this opportunity the story is told by actual record of stream flow upon the following rivers for a period during which the mountain forests on their watersheds were rapidly denuded. These are such as the Ohio, Monongahela, Allegheny, Cumberland, Alabama, Savannah, Wateree, Congaree, and Muskingum.

That surface conditions affect stream flow is shown by the record of streams whose naturally treeless watersheds by cultivation have been made more retentive of water. The principal watershed of the Red River lies in the prairie country of western Texas and Oklahoma. With slightly decreased rainfall this stream shows during the last sixteen years a marked decrease in the frequency and duration of floods and of low water. During this period much of its watershed has been cultivated, groves have been planted, and fires checked, resulting in a larger capacity for the absorption and storage of water.

That forests hold soil and that hillsides denuded of forest do not hold their soil is to be seen in any mountain region in the United States. One small stream has been found by actual measurement to deposit silt in one year equal to 1½ tons per acre of its watershed. For the whole United States the loss of soil each year is from one to two thousand million tons. At the lowest estimate the total quantity of silt carried by our streams would cover 1 foot deep a surface of more than 900 square miles. The larger part of it is deposited in the lower courses of our streams and in our harbors, a menace to navigation and to present developed water powers, and a handicap to their development.

The National Forests in the Rocky Mountain and Pacific coast States afford summer ranges to over 12 per cent of the cattle and 21 per cent of the sheep in the States in which they lie. If this live stock were not fed in the forests during the summer months it would be without natural forage during the winter. For the East, the number of forest-fed live stock can not be given. But notably in the southern pine belt and in the southern mountains, live-stock owners, especially small holders, turn out their sheep, cattle, and hogs in the forests for the larger part of each year.

That the existence of nearly all kinds of wild game depends directly upon the conservation of the forest is well known. The deer killed in six States alone in the northeast represents each year a food value of over $1,000,000. The raw furs exported yearly from the United States are worth $7,000,000 to $8,000,000, and raw furs worth in the aggregate still more are kept for manufacture here. Most of these furs are taken from forest animals. Relatively few kinds of fresh-water fish, and mainly those of inferior food value, will endure in streams fed from denuded watersheds.

WHAT WE HAVE.

Our forests now cover 550,000,000 acres, or about one-fourth of the United States. The original forests covered not less than 850,000,000 acres.

Forests publicly owned contain one-fifth of all timber standing. Forests privately owned contain at least four-fifths of the standing tim-

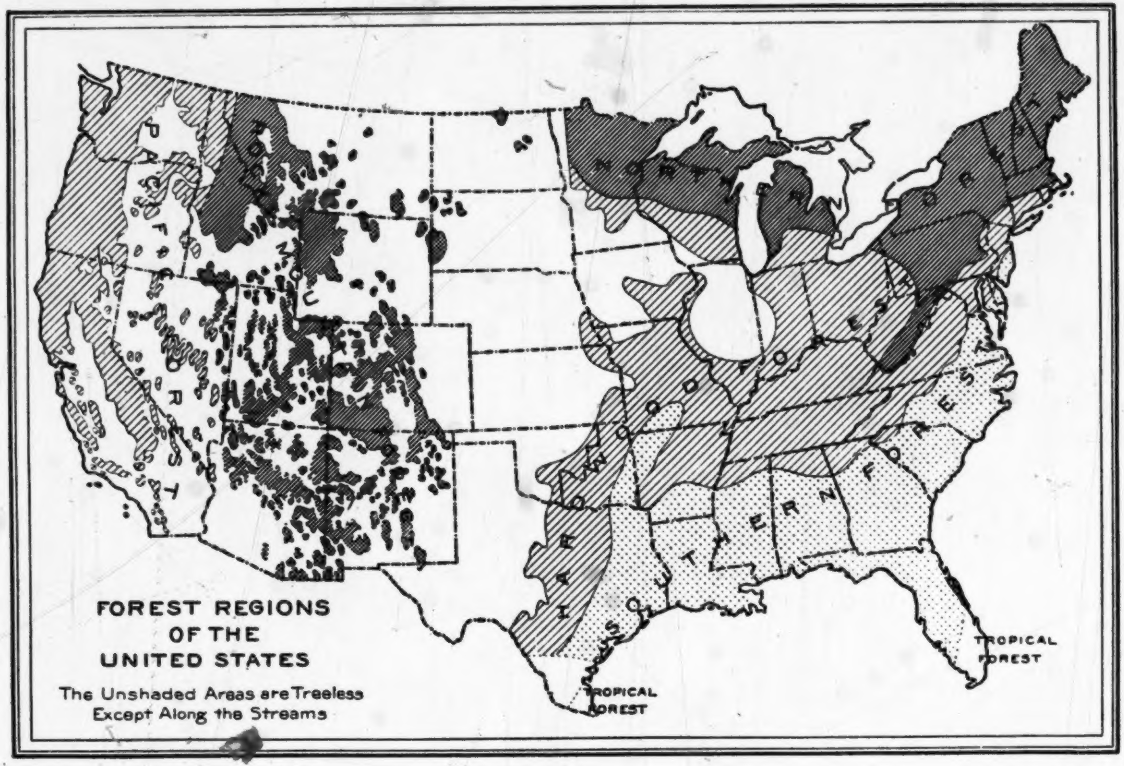

FOREST REGIONS
OF THE
UNITED STATES
The Unshaded Areas are Treeless
Except Along the Streams
PACIFIC FOREST
ROCKY MOUNTAIN FOREST
NORTHERN FOREST
HARDWOOD FOREST
SOUTHERN FOREST
TROPICAL FOREST
TROPICAL FOREST

FIG 1.

ber. The timber privately owned is not only four times that publicly owned, but it is generally more valuable.

Forestry is now practiced on 70 per cent of the forests publicly owned and on less than 1 per cent of the forests privately owned, or on only 18 per cent of the total area of forests.

The original forests of the United States contained timber in quantity and variety far beyond that upon any other area of similar size in the world. They covered 850,000,000 acres, with a stand of not less than 5,200,000,000,000 board feet of merchantable timber, according to present standards of use. There were five great forest regions—the northern, the southern, the central, the Rocky Mountain, and the Pacific. (See fig. 1.)

The northern forest was the home of the white pine. With it grew red pine, spruce, hemlock, cedar, balsam fir, and several hardwoods. Before clearing and logging began, the northern forest probably covered 150,000,000 acres, and contained not less than 1,000,000,000,000 board feet. In the southern forest the yellow pines were the most common trees, with hard woods on the better soils and cypress in the swamps. The southern forest probably covered 220,000,000 acres and contained at least 1,000,000,000,000 board feet. The central forest was nearly all hardwoods, among which the more important were oak, yellow poplar, elm, hickory, chestnut, red gum, ash, and walnut. Its area was about 280,000,000 acres and its stand 1,400,000,000,000 board feet. The Rocky Mountain forest was coniferous and grew mainly upon the mountains. Western yellow pine was the most common tree, with lodgepole pine, larch, spruce, western red cedar, western white pine, and Douglas and other firs abounding locally. The Rocky Mountain forest covered about 110,000,000 acres with a stand of 400,000,000,000 board feet. The Pacific forest was nearly all evergreen, chiefly Douglas fir, western yellow pine, redwood, western red cedar, sugar pine, and several other firs, cedars, and spruces. Its trees were the largest and its stands the heaviest recorded by history or by geology. The Pacific forest probably contained 90,000,000 acres, with a stand of 1,400,000,000,000 feet.

As well as these great forest regions, the United States probably contained 100,000,000 acres, chiefly in the West, of scrubby forests and brush land, of great value in conserving stream flow and for fuel, posts, and other small material.

Our present forests, except upon the Pacific coast and in the Rocky Mountains, are mere remnants of those which once covered 45 per cent of the country. Clearing for agriculture, logging, and fire have reduced this to 29 per cent, or 550,000,000 acres, with a probable stand of 2,500,000,000,000 board feet. The northern forest now contains 90,000,000 acres, or 60 per cent of its former area; the southern forest 150,000,000 acres, or 68 per cent; the central forest 130,000,000 acres, or 46 per cent; the Rocky Mountain forest 100,000,000 acres, or 91 per cent; and the Pacific forest 80,000,000 acres, or 89 per cent of its original acreage.

Fire, careless cutting, and excessive grazing have greatly injured the composition and quality of existing forests. No native tree has yet become entirely extinct, but the commercial supply of every kind, except those of the Pacific forest, is seriously reduced. The following estimates of the quantity of timber publicly and privately owned have been compiled by the National Conservation Commission.

Forests publicly owned are nearly all in the West. (See fig. 2.) They consist of National Forests, national parks, Indian reservations, military reservations, the forests of the unreserved public domain, and state forests. They contain over 100,000,000 acres of merchantable timber, with a stand of 484,200,000,000 board feet, distributed as follows:

Public forest lands.

		Total stand.
In national forests	board feet	390,000,000,000
In national parks	do	11,000,000,000
In unreserved public domain	do	14,000,000,000
In Indian reservations	do	34,000,000,000
In military reservations	do	200,000,000
In state forests	do	35,000,000,000
Total	do	484,200,000,000

Forestry is practiced on 70 per cent of these public forests.

Forests privately owned fall into two classes—farmers' woodlots and larger private holdings. Woodlots contain 300,000,000,000 board feet of saw timber and 1,500,000,000 cords of wood. They cover 200,000,000 acres, 95 per cent of which is in the region east of the plains, where woodlots form about one-half the forest. Woodlots consist in the main of scattered patches of original forest, from which the best timber has been cut. They are made to yield little saw timber, but furnish the chief supply of fuel, posts, and rails, and of wood for other domestic and some local uses. Particularly in the East woodlots furnish a considerable number of hewn ties. Through their location among farm lands and their small individual area, woodlots suffer less damage from fire than do large timber tracts. But they are seldom conserved by the regulation of either cutting or grazing.

Corporate holdings with the larger individual holdings contain about 1,700,000,000,000 feet of timber. This is, on the average, the most valuable timber in the United States. Forestry is practiced on much less than 1 per cent of the timber tracts privately owned.

WHAT IS PRODUCED.

The yearly growth of wood in our forests does not average more than 12 cubic feet per acre. This gives a total yearly growth of less than 7,000,000,000 cubic feet.

Nearly all our native commercial trees grow much faster than those of Europe. We already grow post timber in twenty to thirty years, mine timber in twenty-five to thirty-five years, tie timber in thirty-five to forty years, and saw timber in thirty to seventy-five years.

We have 200,000,000 acres of mature forests, in which yearly growth is balanced by decay; 250,000,000 acres partly cut over or burned over, but restocking naturally with enough young growth to produce a merchantable crop; and 100,000,000 acres cut over and burned over, upon which young growth is either wholly lacking or too scanty to make merchantable timber.

That our forests grow very slowly, although the individual trees of many kinds grow fast, is our fault. In Europe, forests composed of trees growing much slower than most of ours produce over four times as much because the forests are cared for.

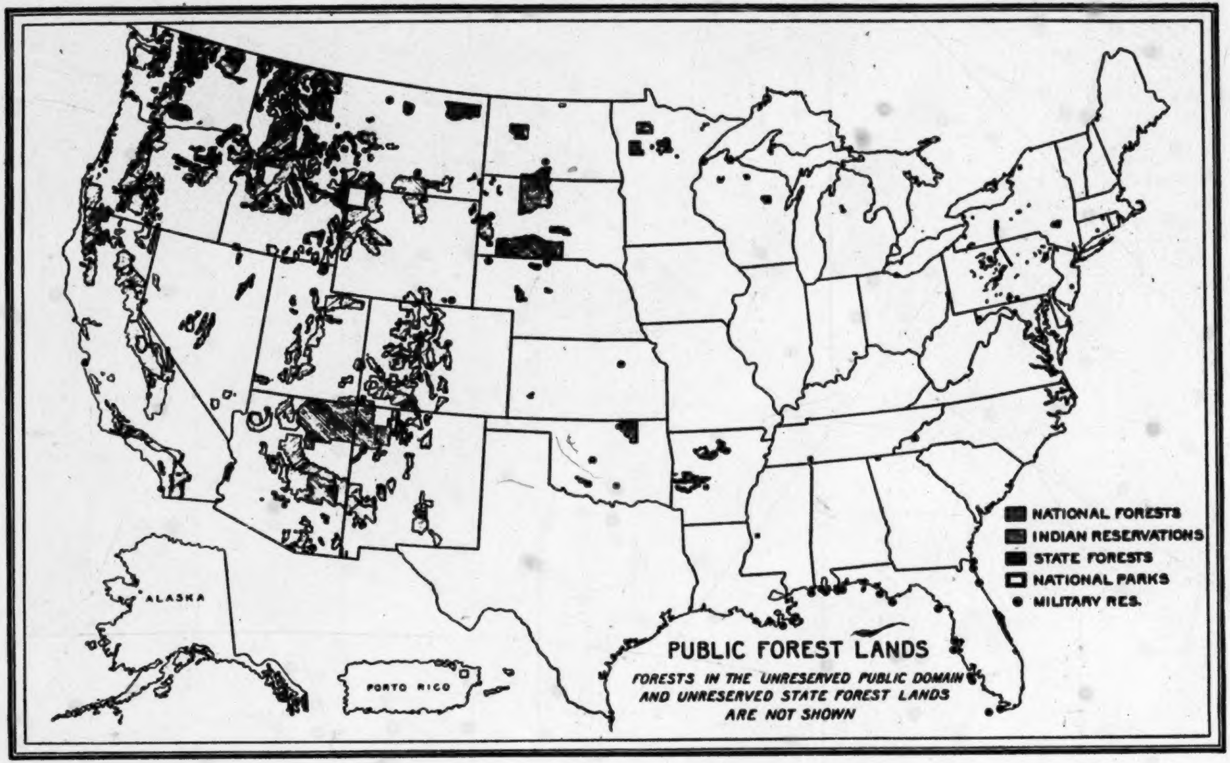

NATIONAL FORESTS
INDIAN RESERVATIONS
STATE FORESTS
NATIONAL PARKS
MILITARY RES.
PUBLIC FOREST LANDS
FORESTS IN THE UNRESERVED PUBLIC DOMAIN AND UNRESERVED STATE FOREST LANDS ARE NOT SHOWN
ALASKA
PORTO RICO

FIG. 2.

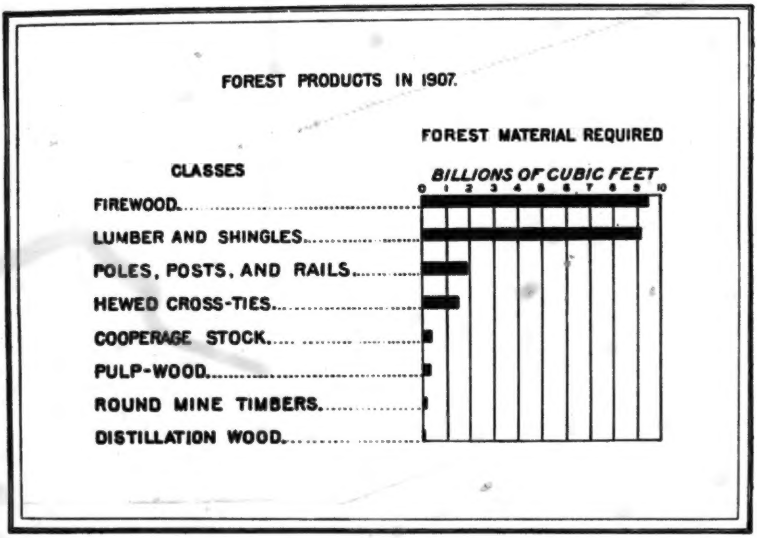

FOREST PRODUCTS IN 1907.
FOREST MATERIAL REQUIRED
CLASSES
BILLIONS OF CUBIC FEET
0 1 2 3 4 5 6 7 8 9 10
FIREWOOD
LUMBER AND SHINGLES
POLES, POSTS, AND RAILS
HEWED CROSS-TIES
COOPERAGE STOCK
PULP-WOOD
ROUND MINE TIMBERS
DISTILLATION WOOD

FIG. 3.

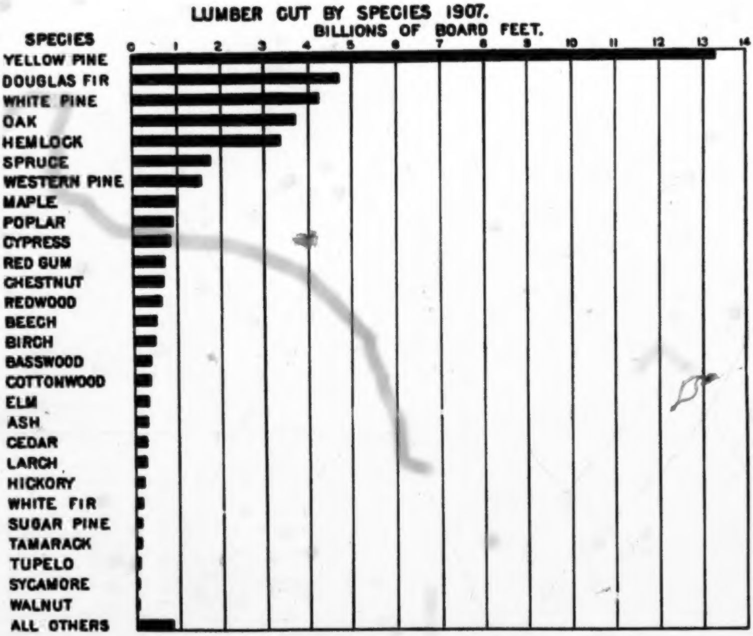

LUMBER CUT BY SPECIES 1907.
BILLIONS OF BOARD FEET.
SPECIES
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
YELLOW PINE
DOUGLAS FIR
WHITE PINE
OAK
HEMLOCK
SPRUCE
WESTERN PINE
MAPLE
POPLAR
CYPRESS
RED GUM
CHESTNUT
REDWOOD
BEECH
BIRCH
BASSWOOD
COTTONWOOD
ELM
ASH
CEDAR
LARCH
HICKORY
WHITE FIR
SUGAR PINE
TAMARACK
TUPELO
SYCAMORE
WALNUT
ALL OTHERS

FIG. 4.

We have twenty important kinds of trees which produce in one hundred years or less, timber fit for the saw. In favorable localities, cottonwood, red gum, white ash, and loblolly pine in the South, and redwood, Douglas and other firs, Sitka spruce, and western yellow pine on the Pacific coast, will grow saw timber in thirty to seventy-five years.

Under present conditions, chestnut, cypress, redwood, yellow poplar, red and black oak, loblolly, jack, red and white pine, and western yellow pine will grow post timber, four to eight inches in diameter, in fifteen to thirty years. We are already getting mine props in twenty-five to thirty-five years from red or black oak and loblolly pine, from white oak in forty-five years, from red pine in forty years, from lodgepole pine in sixty years, from western yellow pine and Douglas fir in the Rocky Mountains in fifty years and on the Pacific coast in thirty-five years.

The time now needed to grow a tie in our forests runs from thirty-five years for red gum to one hundred and fifty years for white cedar and tamarack in the northern swamps. Douglas fir and western yellow pine on the Pacific coast, and chestnut, red oak, and loblolly pine are, on the average, making tie timber in forty to forty-five years, cypress in sixty-five years, longleaf pine in seventy-five years, white oak in eighty years, lodgepole pine in the Rockies, and beech, in 100 years, and western hemlock in one hundred and thirty years.

These figures are taken from measurements of trees grown in forests not conservatively managed. In the same forests, conservative management would, as the result of greater density, less unsoundness, and the growing of desirable kinds, not only yield several times as much timber in the same period, but would increase the growth of individual trees.

The 200,000,000 acres of mature forest in the United States is mainly in the northern Rockies and on the Pacific coast, the very regions in which the immature forests grow most rapidly. The 250,000,000 acres partly cut or burned over but restocking naturally with young growth are mostly in the southern mountains and in the southern pine belt. The 100,000,000 acres cut over and burned over, upon which young growth is wholly lacking or too scanty to make merchantable timber, are chiefly in the Lake States and in the southern pine belt.

WHAT IS USED.

We take from our forests yearly, including waste in logging and in manufacture, 23,000,000,000 cubic feet of wood.

We use each year 100,000,000 cords of firewood, 40,000,000,000 board feet of lumber, more than 1,000,000,000 posts, poles, and fence rails, 118,000,000 hewn ties, 1,500,000,000 staves, over 133,000,000 sets of heading, nearly 500,000,000 barrel hoops, 3,000,000 cords of native pulp wood, 165,000,000 cubic feet of round mine timbers, and 1,250,000 cords of wood for distillation.

The volume of wood needed in 1907 to produce each of these great products is shown graphically in figure 3. The kind and quality of timber used for these products vary enormously. The great bulk of firewood comes from farmers' woodlots or from forests already logged. Some of it is made from wood unfit for any other use. But a large part is taken from immature trees, especially hardwoods of kinds valuable for lumber.

Lumber and shingles are usually made from large timber of high quality. Lumber is being made in commercial quantities from thirty kinds of trees. The amount cut from each of them is shown in figure 4. Softwoods furnish 77 per cent of our total yearly lumber supply, and hardwoods 23 per cent.

The southern pines furnish over 30 per cent of our lumber; Douglas fir about 12 per cent; white pine, 10 per cent; oak, 9 per cent; and hemlock over 8 per cent.

The lumber cut in 1907, by States, is shown in figure 5. Washington was first, with 9.4 per cent; Louisiana second, with 7.4 per cent; Texas came next, with 5.5 per cent; and Mississippi, Wisconsin, and Arkansas followed closely, with about 5 per cent each.

The center of lumber supply in the United States shifts constantly, as one region is cut over and another is attacked. The relative production of ten States in 1880 and 1907 is shown in figure 6.

In 1880 these ten States produced 53.8 per cent of the total cut of 18,125,432,000 board feet, and in 1907 they produced 52.4 per cent of the total cut of 40,256,154,000 board feet. The changes in the output by States are striking. Michigan supplied 23 per cent of the total lumber output in 1880 and 4.5 per cent in 1907. Washington yielded less than 1 per cent in 1880 and over 9 per cent in 1907.

Over three-fifths of our shingles are made from western red cedar, chiefly in Washington, and the remainder mainly from eastern white cedar, cypress, and redwood. Telephone, telegraph, and electric light and traction companies use each year between three and four million poles in various lengths above 20 feet. Three-fifths of these are white cedar, cut chiefly in the Lake States, and over one-fourth is chestnut. Much cedar and chestnut, as well as many woods common to other regions are used for smaller-sized poles and for posts and fence rails. The oaks, chiefly white oak, furnish over 45 per cent of the hewn railroad ties. The cutting of young oak for ties, next to the cutting of oak logs for lumber, is the most serious drain upon our oak forests. Other kinds much used for ties are the southern and western pines, cedar, chestnut, cypress, and hemlock. Many woods are used for slack cooperage stock, of which the chief are red gum, pine, elm, beech, and maple. A large part of the tight cooperage stock is high-grade white oak, which results in another heavy drain upon the oak forests.

Our paper and pulp mills use over 3,000,000 cords of native wood each year and import more than 900,000 cords from Canada. Nearly three-fifths of the native pulp wood is spruce, cut mostly in the Northeastern States, and one-fifth is hemlock, which comes chiefly from Pennsylvania and Wisconsin.

The cutting of mine timbers takes each year great quantities of immature timber from forests in the mining regions, the kinds used varying with the locality.

Nearly all wood used for distillation is beech, birch, and maple. In relatively few cases this wood is saved from the waste in logging.

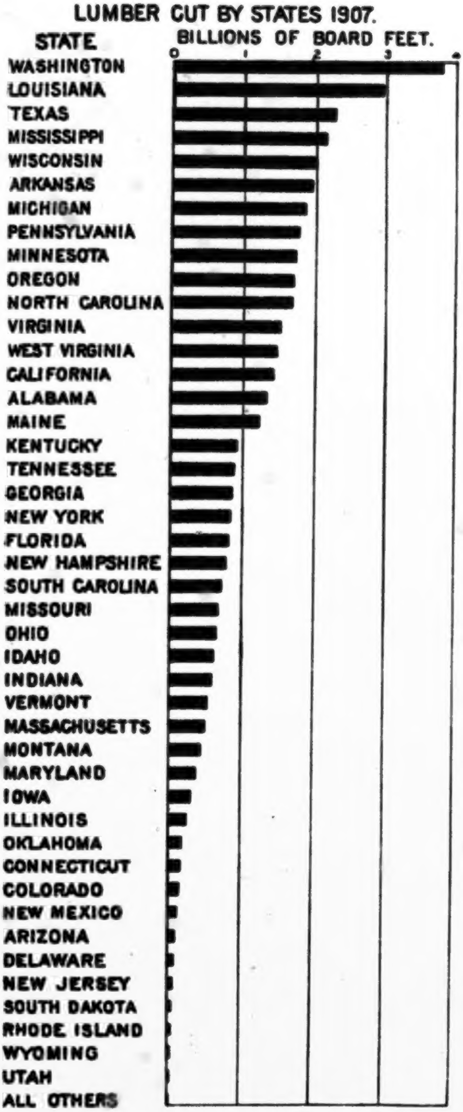

LUMBER CUT BY STATES 1907.
STATE
BILLIONS OF BOARD FEET.
0
1
2
3
4
WASHINGTON
LOUISIANA
TEXAS
MISSISSIPPI
WISCONSIN
ARKANSAS
MICHIGAN
PENNSYLVANIA
MINNESOTA
OREGON
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
CALIFORNIA
ALABAMA
MAINE
KENTUCKY
TENNESSEE
GEORGIA
NEW YORK
FLORIDA
NEW HAMPSHIRE
SOUTH CAROLINA
MISSOURI
OHIO
IDAHO
INDIANA
VERMONT
MASSACHUSETTS
MONTANA
MARYLAND
IOWA
ILLINOIS
OKLAHOMA
CONNECTICUT
COLORADO
NEW MEXICO
ARIZONA
DELAWARE
NEW JERSEY
SOUTH DAKOTA
RHODE ISLAND
WYOMING
UTAH
ALL OTHERS

FIG. 5.

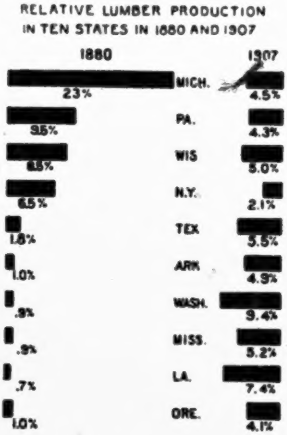

RELATIVE LUMBER PRODUCTION
IN TEN STATES IN 1880 AND 1907
1880
1907
MICH.
23%
4.5%
PA.
9.5%
4.3%
WIS
8.5%
5.0%
N.Y.
6.5%
2.1%
TEX
1.8%
5.5%
ARK
1.0%
4.9%
WASH.
.9%
9.4%
MISS.
.9%
5.2%
LA.
.7%
7.4%
ORE.
1.0%
4.1%

FIG. 6.

WHAT IS WASTED.

Since 1870 forest fires have each year destroyed an average of fifty lives and $50,000,000 worth of timber. Not less than 50,000,000 acres of forest are burned over yearly. The young growth destroyed by fire is worth far more than the merchantable timber burned.

One-fourth of the standing timber is left or otherwise lost in logging. The boxing of longleaf pine for turpentine has destroyed one-fifth of the forests worked. The loss in the mill is from one-third to two-thirds of the timber sawed. The loss in the mill product through seasoning and fitting for use is from one-seventh to one-fourth. Great damage is done by insects to forests and forest products. An average of only 320 feet of lumber is used for each 1,000 feet which stood in the forest.

Prodigious waste has accompanied our use of the forest. The chief causes are fire, wasteful methods of logging and turpentining, waste in the mill, and waste in the use of wood.

Forest fires have destroyed many billion feet of commercial timber. They have driven the forest from vast areas, upon which the actual planting of trees will be needed before the forest will return to them. They have destroyed or injured young growth whose value is much more than that of the timber burned. They have changed greatly for the worse the quality and composition of existing forests. To them is due, far more than to the wasteful logging which they have usually followed, the decline in the utility of our streams for all useful purposes; and, through erosion, forest fires are working destructive change in the configuration of the land itself.

The average waste in the woods is 1,000 board feet to every 4,000 board feet logged. This is due to a variety of causes, many of which could be wholly removed with both present and permanent profit, and all of which could be greatly reduced with the same result. Chief among them are plans for logging poorly made or poorly carried out; the leaving of merchantable timber in the woods either actually cut or in dead trees, trees partly unsound, or trees of the less valuable kinds; the waste of timber in high stumps and long tops, and in the failure to cut logs to such lengths that the tree is most profitably used; breakage in felling, loss in lodged trees, and in driving; and the use of good timber for temporary construction in logging, for which inferior timber would serve equally well. But still more serious than all these forms of waste combined, in its effect upon the future timber supply, is the well-nigh universal damage in logging, for the most part wholly unnecessary, to the young growth.

The experience of half a century has clearly shown in Virginia, the Carolinas, and Georgia that turpentining under present methods renders a permanent naval-stores industry in the South utterly impossible. These methods usually render the forest unproductive in four or five years. They have so greatly reduced the longleaf-pine forests available for turpentining that in some localities trees 4 or 5 inches in diameter are now being boxed. This generally means an exceedingly low return in turpentine and the death in a year or two of trees, which would otherwise have grown to make lumber.

In the mill logs lose from 30 to in some cases as much as 70 per cent of the volume of timber they contain. Two-thirds of this, under present conditions, is an unavoidable waste. One-third can practically and profitably be avoided. In the manufacture of lumber, which forms over nine-tenths of the total mill product, the merchantable output is about two-thirds the contents of the log, not including the bark. For the entire lumber cut of the United States under present practice the saw kerf forms on the average 13 per cent of the total volume of the log, edgings and trimmings 9 per cent, and slabs 9 per cent. Cutting to standard lengths and widths, carelessness in manufacture, and accidents cause a loss of 5 per cent.

The waste in seasoning, in the factory, and in the use of the final product is far more difficult to estimate closely. In the building trades the waste in seasoning from staining, warping, and checking, and the loss in fitting material to final forms are not less than 15 per cent. The waste in cutting stock to required sizes and in eliminating defects is 20 per cent in box factories and 25 per cent in furniture factories.

In the aggregate great damage is done each year to standing and cut timber by injurious forest insects. Much of this damage can be prevented at small expense. The application, practically without cost, of simple preventive measures against injurious forest insects and insects which attack forest products would greatly reduce the unnecessary losses which they occasion. The protection of the forest from insect depredations, both by preventive measures such as conservative logging and by remedial measures when necessary, is no less a part of practical forestry than is the protection of the forest from fire. The damage to timber standing and cut by insect attack is not so generally apparent nor so generally understood as the damage to the forest by fire. But the injury done is both great and constant. Unless forest owners take vigorous steps against it wherever it threatens still larger losses will inevitably ensue.

Great causes of waste, vast in their effect upon our forests, are the general failure to realize that the cost of growing timber as well as logging and manufacture must be reckoned in its value; and tax laws which force men to realize immediately on their holdings and so lead to unprofitable and wasteful logging, and which compel the abandonment of cut-over lands for taxes.

WHERE WE STAND.

We take from our forests each year, not counting the loss by fire, three and one-half times their yearly growth. We take 40 cubic feet per acre for each 12 cubic feet grown; we take 260 cubic feet per capita, while Germany uses 37 cubic feet and France 25 cubic feet.

We invite by overtaxation the misuse of our forests. We should plant, to protect farms from wind and to make stripped or treeless lands productive, an area larger than that of Pennsylvania, Ohio, and West Virginia combined. But so far, lands successfully planted to trees make a total area smaller than Rhode Island. And year by year, through careless cutting and fires, we lower the capacity of existing forests to produce their like again, or totally destroy them.

The condition of the world supply of timber makes up already dependent upon what we produce. We send out of our country one and one-half times as much timber as we bring in. Except for finishing woods, relatively insignificant in quantity, we must grow out own supply or go without.

By wasteful logging, fire, and general failure to provide for a second crop we have made our forests less productive than any others of similar area in the world, in spite of the remarkably quick growth of most of our timber trees. We have taken our dividends out of our forest capital until we have greatly reduced the capital itself. Our use of wood per capita is larger than that of any other nation. Canada, which has 60 acres of forest per capita to our 6, uses less than 200 cubic feet per capita; Germany uses 37 feet, France 25 feet, and Great Britain 14 feet. We use 260 cubic feet.

We have 65,000,000 acres of cut-over and burned-over forest land, upon which actual planting will be necessary to produce a merchantable crop of timber. Of the 9,500,000 acres of forest cut over each year, 1,000,000 acres is cleared for farms; 5,750,000 acres is restocking naturally with enough young growth to produce a merchantable crop; and 2,750,000 acres go to increase our national task in forest planting. But the entire area already planted successfully in our whole history is less than one-fifth of that upon which we destroy the forest every year.

White pine is so nearly used up that the lumber sawed from it in the Lake States has fallen off 70 per cent since 1890, and since 1900 over 45 per cent in the whole country. We make 16 per cent less oak lumber and 22 per cent less yellow poplar lumber than we did seven years ago. Douglas fir and yellow pine, now our chief source of supply, are going far quicker than they grow, and the yellow pine is going very rapidly. Yellow pine lumber costs 65 per cent more at mill than it did in 1900; Douglas fir costs 63 per cent more; white pine 53 per cent more; oak 54 per cent, yellow poplar 78 per cent, and hemlock 55 per cent more.

We tax our forests under the general property tax, a method of taxation abandoned long ago by every other great nation. In some regions of great importance for timber supply, and in individual cases in all regions, the taxation of forest lands has been excessive and has led to waste by forcing the destructive logging of mature forests, as well as through the abandonment of cut-over lands for taxes. That this has not been even more general is due to under-assessment, to lax administration of the law, but to no virtue in the law itself. Already taxes upon forest lands are being increased by the strict enforcement of the tax laws. Even where this has not yet been done, the fear that it will be done is a bar to the practice of forestry.

The protection of all public forests from fire is not yet achieved, and an average of 1 acre in every 10 of forest privately owned is burned over yearly. Many of these fires destroy little or no old growth, but wherever fire runs in our forests it either reduces or destroys their capacity to produce again.

We send wood out of the country, and we bring it in. But for each billion feet brought in we send out 1,500,000,000 feet, and the total difference goes to increase by nearly 1 per cent the yearly drain upon our forests. No other country is or will be in a position to meet our needs. Europe imports more wood than she exports. Africa imports structural timber, and can export only expensive hardwoods. The same is true of India, the chief forest country of Asia. China imports wood, and will require any surplus furnished by Siberia and Manchuria. Japan should finally supply her own needs. The Philippines now import much timber, but should eventually grow it, with some surplus for export to China. The total stand of merchantable timber in the Philippines is about equal to the lumber cut in the United States for two years. Alaska has probably as much as the Philippines. Hawaii can export only hardwoods in small quantities. Mexico and Central and South America import structural timber and export mahogany and cedar. South America has great forests which when utilized and cared for should supply the home market. We get about 900,000,000 feet of lumber and 900,000 cords of pulp wood from Canada each year, or 2 per cent of the lumber and 23 per cent of the pulp wood which we use. Canada has more spruce pulp wood than we have, but her standing saw timber is only about one-third of ours. Canada will eventually require all the lumber which her forests can grow.

Whether we take care of our forests, or whether we do not, we can expect (save for a trifling quantity of finishing woods) to use what timber they grow, and no more.

The records prove that, other factors remaining constant, industrial progress is accompanied by increased consumption of wood. This fact is so universally manifest that it can not be thought an accident. It may be regarded as a law of industrial life.

It might be supposed that the substitution of other materials for wood which takes place with industrial progress would decrease the per capita need of wood, but such is not the fact. Substitutions may diminish consumption for specific purposes, but this is more than made up for by the development of needs for wood along new lines or of greater needs along old lines. Only rising prices can serve to lessen the consumption of wood by an advancing nation, and after wasteful use has been cut off, any further reduction means an economic disadvantage. It means harder conditions of life, a handicap on industry.

In the United States our use of wood is lavish. By better methods in the woods, at the mill, and in ways of use we can make what we have go further than we are now making it go, without industrial hardship. On the other hand, our legitimate need will certainly not decline but advance as we go on to greater industrial strength. We can without hardship reduce our per capita consumption through economies; but after we have reached a reasonable basis we must expect to see our needs advancing again. We are like a growing family which is extravagantly living beyond its income, but which is sure to need, when it has cut off extravagant use, an advancing income through future years.

WHAT SHOULD BE DONE.

We should stop forest fires. By careful logging we should both reduce waste and leave cut-over lands productive. We should make the timber logged go further by preservative treatment and by avoiding needless loss in the woods, the mill, the factory, and in use. We should plant up those lands now treeless which will be most useful under forest. We should so adjust taxation that cut-over lands can be held for a second crop. We should recognize that it costs to grow timber as well as to log and saw it.

We should continue and perfect, by State and nation, the preservation by use of forests already publicly owned; and we should extend it to other mountain forests more valuable for the permanent benefit of the many than for the temporary profit of a few.

For each million acres of forest in public ownership over 4,000,000 are privately owned. The conservation of public forests is the smaller task before the nation and the States. The larger task is to induce private forest owners, which means 3,000,000 men, to take care of what they have, and to teach wood users, which means every one, how not to waste.

If these things are done, they will conserve our streams as well as our forests. If they are not done, the usefulness of our streams will decrease no less than the usefulness of our forsets.

THE DUTY OF THE PRIVATE OWNER.

Four-fifths of our standing timber is in private hands. The conservation of our forests and of the timber used depends mainly upon individual forest owners and users. If American citizens will protect their forests from fire, will provide by conservative logging for a good second crop, and will take every reasonable precaution against the waste of timber in the woods, in the mill, in the factory, and in use, their forests will eventually supply more than their need, continuously. If these things, each one of which will pay now and in the future as well, are not done, this nation will ultimately be dependent upon public forests. These, if cut absolutely clean, would furnish only enough lumber to meet our national need for ten years. At the end of that time they would be exhausted. If we are to be saved from great suffering for lack of timber, the forests of private owners must supply the timber.

STOPPING FOREST FIRES.

Forest fires are preventable at a cost slight in itself and insignificant compared with the value of the timber they destroy. Experience on the National Forests has shown that the way to keep down fires is to employ men to watch for them during the fire season. An expenditure of a few hundred dollars in employing men to patrol during the dangerous part of the year is vastly more effective than the expenditure of many times this sum in the attempt, often futile, to put out fires already under headway.

The cost per acre of protecting the forest from fire varies directly with the density of settlement, with local sentiment, with the character of the country and of the forest, with the means of transportation and communication, and with the length of the fire season.

Studies made by the Department of Agriculture and the experience of private owners who are protecting their forests from fire show that the forests of the southern mountains and of the southern pine belt can be effectively patrolled for 2 cents per acre per year. The northern forests can be patrolled thoroughly for not more than 4 cents per acre, and the Rocky Mountains and Pacific coast forests for 1½ cents per acre. These estimates mean, if their owners would cooperate effectively, that all forests in private hands in the United States can be protected from fire for less than $10,000,000 a year—about the cost of one *Dreadnought*. It also means that at an expenditure of $10,000,000 a year, a yearly loss in merchantable timber of about $50,000,000 would be prevented. This does not count the saving in young growth.

The best methods of fire protection for private owners vary greatly with the conditions which fix its cost. But for all regions the following principles are sound on tracts of some size:

1. Employ an adequate force whose first duty is to patrol against fires. Give them all the tools they need, and mount them if they can so work more effectively. In the South and in the Rocky Mountains a mounted patrol is best. In many parts of the northern and Pacific forests, men can do their best work on foot.

2. Increase the efficiency of the fire-fighting force and reduce its size by building trails for patrol. Telephone lines can be built cheaply and if properly distributed throughout the forest, and combined with a good trail system, will increase several times the area which can be effectually patrolled by one man.

3. Build up a local sentiment against fires by making the damage they do plain to all.

4. Cooperate in fire patrol with other forest owners, Above all cooperate with those who own tracts contiguous to your own. This will render your patrol and theirs not only cheaper but vastly more effective.

FOREST PLANTING.

Forest planting means the protection of denuded watersheds from erosion, and the protection of farm homes and crops from wind and cold. In many localities, it means the production of timber near by instead of bringing it from a distance at much greater cost.

The United States contains 65,000,000 acres of stripped land, suitable only for the growing of trees, which will not bear a productive forest again except through the actual planting of trees, or sowing of tree seeds. The West contains 16,000,000 acres of naturally treeless land which should be planted to trees in the interest of agriculture in the prairie region and on irrigated lands elsewhere. Thus far, we have planted in all less than 1,000,000 acres, of which probably less than one-half is successful, because we have planted, for the most part, without adequate knowledge of where, what, and how to plant.

As regards the need for tree planting, the United States naturally falls into three regions—the Eastern, the Central, and the Western.

The Eastern region lies east of the prairie States. In it the planting of trees for the production of timber is of much more importance than for protection to stream flow or to crops. It contains lands of the following classes, which can be planted with profit to their owners:

Cut-over lands not good to farm, upon which, usually as a result of repeated fires after logging, natural reproduction is not taking place. Lands suitable only for forest, but which have been cleared, farmed unsuccessfully, and then abandoned. Woodlots in which planting is necessary to supplement natural reproduction or to take its place.

Cut-over and burned-over lands in need of planting aggregate 3,500,000 acres, and occur mainly in the Adirondack region and in the northern portion of the lake States; abandoned farm lands occur mainly in New England and in the southern mountains; unproductive woodlots are characteristic chiefly of the region west of the Appalachians and east of the prairies.

The Southern States contain about 12,000,000 acres upon which natural reproduction is insufficient or lacking, but upon which adequate fire protection will in the main restore good forest conditions. In the eastern region about 92,000 acres have been planted, of which 5,000 acres are state forest lands.

The Central region comprises the prairie country, which includes Illinois, Iowa, North Dakota, South Dakota, Nebraska, and Kansas, the prairie district of Minnesota, and those parts of Oklahoma and Texas which lie west of the hardwood belt. It contains about 14,000,000 acres, which should be planted to trees for the protection of crops from wind, to reduce evaporation, and to grow timber for farm and other local uses. Planting already covers 831,000 acres in this region, and wherever rightly done yields remarkably high profit.

The Western region includes the Rocky Mountain and Pacific coast States. In it the planting problem is mainly Federal. Not less than 5,000,000 acres or about 3 per cent of the area of the National Forests must be planted to protect watersheds, and to increase the production of timber. Southern California alone contains probably not less than 1,000,000 acres outside National Forests which are now unproductive and could be made productive under trees. Planting is necessary upon nearly 3,000,000 acres to protect crops on irrigated lands in the western region. Private owners have planted only 37,000 acres of such lands thus far. On national forests experimental planting and sowing has been done upon 1,762 acres. This has been carefully planned and carried out, and already furnishes the knowledge required for successful planting on a large scale, as soon as the necessary funds are available.

To sum up, our task in forest planting is vast. Thus far in actual acreage successfully planted our accomplishment is wholly inadequate. The area of naturally treeless lands already planted is utterly insignificant in comparison with their total extent. Upon denuded forest lands we have planted only 1 acre to each 10,000 we have to plant.

RECOGNIZING THE VALUE OF TIMBER.

We have manufactured more lumber and other forest products than we require. That is, we have established a consumption per capita, based not merely on actual need, but on a lavishness, a disregard for possible substitutes, and a scale of waste in the use of wood, equaled in no other country. Supply has been regulated to a demand swollen not so much by industrial development, great as it has been, as by a product unduly cheap, because the items of logging and manufacture were considered the main costs of producing it. The cost of growing the trees has always been left out.

That there is, in the economic sense, overproduction of lumber is wholly true, because we manufacture more lumber than our forests can yield permanently. No economic reason fully explains the difference between the price of lumber grown in the United States and of lumber grown in Europe. Difference in the density of population explains it only in part. But neither that nor the relation of supply to demand is the chief cause. It lies in our failure to realize that if we are to grow timber continuously to meet our needs its value must be reckoned by the cost of growing it as well as by the cost of logging and manufacture. Stumpage prices in the United States average less than one-fifth of the price of lumber at the mill. The value of anything which is needed is at least what it will cost to grow it again.

We pay generally less for lumber than it is worth, with a slight present gain to ourselves individually, and by so doing we discourage the right use of the forest and greatly increase the cost of lumber to ourselves later on, and to those who come after us. We must recognize the actual value of timber now, or pay an excessive price for it in the future, and we have carried destruction so far that we shall probably have to do both.

CONSERVATIVE TURPENTINING.

An important source of waste is boxing small trees, which yield little turpentine and soon die. If left standing, these small trees would make lumber and pay well. Another source of waste is boxing larger trees so deeply that they die in a few years or are blown down, while in the meantime the deep wound made in boxing invites fire. The cup and gutter method of turpentining, introduced by the Federal Government, yields 30 per cent more turpentine and better turpentine, does not invite windfall, and lessens injury from fire. Under this system, combined with other economies still more recently devised, a forest can probably be worked for fifteen to twenty years, and made to yield much more turpentine, with small injury to the merchantable timber.

If improved methods of turpentining are given general use in longleaf pine forests and in the working of other southern and western pines, they will mean both a permanent naval-stores industry, a higher profit to turpentiners, and an important gain in the continuous timber yield of our forests.

CONSERVATIVE LOGGING.

Through careless and destructive logging on private forest lands, an average of 25 per cent of the merchantable timber is left standing, or otherwise wasted in the woods. On National Forests, from which has been sold yearly for the last three years an average of about 250,000,000 board feet of timber, the total waste in logging is about 10 per cent. This timber was sold at prices no lower than those paid for timber of the same kind and quality on private forest lands. It was logged and manufactured by the lumbermen who bought it, and sold by them in the open market, in competition with lumber cut from private forest lands under wasteful methods. Last year the Federal Government was asked by lumbermen to sell at good prices, from National Forests, ten times as much timber as it sold. That it did not make more timber sales was partly because the force on National Forests was not large enough to handle them. But if lumbermen can with profit buy timber at what it is worth from the forest lands of the people, and log it conservatively, they can do at least as well with their own.

Part of the waste in logging is unavoidable under present conditions. The following discussion deals specifically with those items of waste which it is practicable to avoid now, often with higher immediate profit to the owner of the land from which the timber is cut, and always with higher permanent profit from the land itself after it is cut over the first time.

Care for young growth.—The loss to the value of the forest, through injury to young growth in logging, is larger than the waste of merchantable timber. A small part of this damage is unavoidable. Nearly all of it is avoidable without materially increasing the cost of logging. It costs no more money to fell a tree uphill than to damage young growth by felling it downhill. It does not cost much to release young trees bent over by the tops of felled trees. More logging roads, skidding paths, and snake trails than are really needed kill much young growth, and they do not make for cheap logging. Rolling logs down hill is seldom necessary, and it often breaks down young trees which are worth more than the log is worth, to the lumberman who means to hold his cut-over land, or to the men to whom he sells it. Young trees are worth at least as much as it costs to replace them, or about $10 an acre; and $10 an acre spent in forest planting will seldom give us as good a forest as nature will grow for us, if we will take care of the young growth.

Leaving seed trees.—How many and what seed trees to leave, and where, depends on the cost of logging, on the character of the forest, and on the power of its most valuable trees to reproduce themselves. There are no general rules which apply to all forests. It is seldom necessary to leave prime timber as trees for seed. Unsound trees which will probably live long enough to seed up the area, scrubby trees already bearing seed, but unfit for lumber, and thrifty trees too small to be logged with the highest profit now, generally serve the purpose well.

The lumberman who claims that it does not pay to leave seed trees to shed seed, or to take care of young trees, because we may not live to harvest them, forgets these things: that second growth grows much faster than first growth; and that cut-over lands suitable only for forest purposes, which bear young growth, already have a good market value, while cut-over lands bearing neither timber nor young growth have little or no value.

Saving immature trees.—Poor grades of lumber come chiefly from small trees. As the tree gets larger the proportion of choice grades increases. A good many lumbermen are now cutting small trees at a profit, which figured against what they would make from the same trees in ten or twenty years means not profit, but loss. Some lumbermen are cutting small trees at a direct loss.* There is no more fruitful investigation for any lumberman than to figure from the cut of his own mill the volume and grades of lumber sawed from trees of different sizes.

The full use of standing timber.—The failure to cut fire-killed or otherwise damaged timber, to log inferior kinds along with the most valuable kinds, and the leaving of isolated patches which are hard to reach means an average loss to the owner of 1,000,000 to every 10,000,000 feet logged and often much more. It also means much greater danger from fire and insects, and a second growth poor in kind and quality.

Clean work in the woods.—Waste in the woods comes in part from leaving trees, which, though partly unsound or otherwise defective, are still merchantable. It comes in part from high stumps, from trees broken in falling and from lodged trees, from leaving timber in the tops and from failure to cut logs into lengths so as to provide for the fullest possible use of each tree. It comes in part from leaving in the woods, skid poles, ties, camp logs, and other timber used in temporary construction, instead of saving it for pulp, for lumber, or for use again. Especially after deep snow, scattered logs are often left lying in the woods, or even piled on the rollways. In the construction of logging roads and temporary buildings much waste occurs in the unnecessary use of timber of valuable kinds.

There are very few lumbermen in the United States who are not guilty of this waste in one or more forms. The remedy requires no detailed plan. It calls for thorough supervision, for the habit of thrift on the part of the operator, and the enforcement of thrift among his men. A logger who wastes timber in the woods for his employer should be sent out from them just as quickly as a wasteful edgerman or grader is sent out of the mill.

Economy in transportation.—In railroad logging unnecessary loss occurs in the failure to pick up logs fallen from cars or scattered by wrecks.

An average of probably 5 per cent of the timber put into streams for driving is lost. On long drives and rough streams a small part of this damage is unavoidable. But it can probably be reduced on the average by more than half by peeling and drying out logs of kinds which do not float well, by stream improvements, and by reasonable care on the drive itself.

ECONOMY IN THE MILL.

An average of more than one-third of the wood in the log is wasted in the mill. It is practicable, under present conditions, to reduce this nearly one-half. This means the use of thinner saws, of more bandsaws and resaws, and the disuse of gang saws. It means better machinery, more careful manufacture, and the sawing in round edge, or "waney" form of lumber which is worked over again before being finally used. It means the change of grading rules and market usage to admit random widths, odd lengths, and shorter and narrower pieces, and to allow defects which do not seriously reduce the value of the product for the use to which it is to be put. And it means fuller utilization of short boards, slabs, and waste.

MANUFACTURE OF BY-PRODUCTS.

Even when forest products are manufactured and used economically, great opportunity remains for the conversion of wood not utilized in logging or in the mill into useful by-products by chemical and other means. As timber becomes more valuable, we approach more nearly that complete utilization in which every part of the felled trees will be used.

If all the wood wasted in the manufacture of yellow-pine lumber in 1907 had been steam distilled for the production of wood turpentine, it would have yielded more than the total production of gum turpentine in that year. If all the wood wasted in the manufacture of lumber from spruce, hemlock, poplar, and cottonwood in 1907 had been used for paper making, it would have furnished all the paper made from wood in that year. If all the wood which went to waste in the manufacture of chestnut lumber in 1907 had been used to make tanning extract, we would have produced twice as much as was produced from the chestnut cord wood used for this purpose. The waste in the manufacture of beech, birch, and maple lumber in 1907 was nearly equal to the quantity of these woods cut for distillation. The waste in the manufacture of oak lumber was twice the quantity of all hardwoods used for distillation. These are some of the great examples of the failure to use wood fully.

PRESERVATIVE TREATMENT OF TIMBER.

Of all the wood in every form now in use in the United States, decay, fire, insects, and salt water borers destroy not less than the equivalent of 8,000,000,000 board feet each year. Of these, decay is far the most destructive. It is also the easiest to retard. The preservative treatment of timber will lengthen by ten to twenty years the life of woods now commonly used for posts, poles, ties, mine timbers, bridge timbers, and for much other construction work. It will also make profitable the use of many woods which, untreated, decay so quickly that they have little or no value. If preservative treatment makes the life of timber in use twice or three times that of untreated timber, only one-half or one-third as much timber is consumed by that use. Nor does this take into account that large saving in the labor of replacing decayed timber, which in the maintenance of railroad tracks, using untreated ties, is about one-third the cost of the new ties used each year, to keep the track in condition.

In 1907, 1,250,000,000 board feet of timber were treated, which was not more than one-quarter the quantity which could have been treated with profit to its users. There are about 700,000,000 ties in railroad tracks in the United States. They represent, untreated, an average cost per tie of about 12 cents a year. If all were treated the increase in their length of service would mean a saving of 2 3/10 cents per tie per year, or a total annual saving of about $16,000,000. More than $2,000,000 could be saved each year by treating all the poles, and nearly $2,000,000 if all the piling were treated. The saving in timber used in the mines would be about $12,000,000. If lumber so exposed in use that treatment is profitable were treated, the saving would not be less than $15,000,000. This means a total practicable saving of over $47,000,000 a year. It means also that the increased life given these timbers would make an annual saving in wood equivalent to 4,000,000,000 board feet, or 10 per cent of the yearly lumber cut.

Two preservatives are widely used in the United States. These are creosote and zinc chlorid. The chief advantage of creosote is that once injected into wood it prevents decay permanently. Its chief disadvantages are its cost and scarcity. Zinc chlorid is cheaper and an excellent antiseptic. But it will leach out if the treated wood is exposed to moisture.

A farmer can treat a fence post with creosote for about 10 cents and make it last twenty years. Apparatus costing from $50 to $75 will treat from 50 to 100 posts a day, depending upon the kind of timber. The butt of a 30-foot telephone pole can be treated for from 75 cents to $1. The plant will cost from a few hundred to several thousand dollars, depending upon its capacity. Piling properly treated with creosote is not attacked by salt-water borers. Mine timber can be treated with zinc chlorid for from $4 to $5 per thousand board feet. Ties can be thoroughly treated with zinc chlorid for 10 to 12 cents and creosoted for 20 to 30 cents.

USE OF SUBSTITUTES.

Seasoning and factory wastes can be reduced somewhat by improved methods of drying and manufacturing. But a larger part of the necessary saving in the use of timber must come through the substitution of other materials. Stone, brick, steel, and concrete are now less expensive building materials than wood, when depreciation and fire risks are taken into account. Steel is rapidly supplanting lumber in car construction, and concrete, steel, and masonry are taking its place in bridges. Savings possible in building and railway construction alone, if carried to the limit, would diminish by at least one-third the present consumption of lumber. In the furniture industry it is estimated that approximately 50 per cent of the beds now manufactured are made of metal. The use of pressed steel for desks, file cases, and other office furniture is becoming more and more common. To a small extent, as yet, steel is replacing wood for wagon axles, rims, hubs, and spokes, and in the form of thin plates is being used for paneling in wagon bodies.

TASK OF THE STATES.

The States in their relation to the forest face these specific duties: To adjust taxes on forest lands, so that they can be held profitably for forest purposes; to pass good laws for safeguarding forest property from fire, and enforce them; to conserve state forests and extend them to cover other forest lands needed for the permanent benefit of the whole State; and to cooperate with the Federal Government in teaching the people how to take care of their forests.

THROUGH BETTER TAX LAWS.

From now on the relation of taxation to the permanent usefulness of the forest will be vital. Present tax laws prevent reforestation on cut-over land and the perpetuation of existing forests by use. Laxity in their application and special exemptions supply no remedy.

Taxation of forest lands should be based either on the yield when cut or on the earning power of the forest. The former would mean a tax on the land alone, plus a tax on the timber when harvested; the latter would mean an annual tax on the capital value of the forest calculated upon the net returns expected from it. The tax on the timber when cut and an annual tax upon the land itself, exclusive of the timber, has practical advantages. It does not involve forecast of the rate of interest, of the risk of loss by fire, or of timber values, nor does it require exact statistics of the growth of timber.

A tax on the timber when cut and an annual tax upon the land itself, exclusive of the timber, is well adapted to the actual conditions of forest investment, and is practicable and certain. It would insure a permanent revenue from the forest in the aggregate far greater than is now collected, and yet be less burdensome upon the State and upon the owner. It is better from every side that forest land should yield a moderate tax permanently than that it should yield an excessive revenue temporarily, and then cease to yield at all.

THROUGH BETTER FIRE LAWS.

Forest fire laws are ineffective partly because they are wrongly framed, but mainly because they are not enforced. The purpose of forest fire laws is to prevent fires. That principle should obtain in enforcing as well as in drafting them. A fire law inflicting reasonable penalties which is enforced, is much more effective than a fire law inflicting excessive penalties which is loosely applied or waived.

Each State within whose boundaries forest fires are working grave injury, and that means every forest State, must face the fact squarely that to keep down fires needs not merely a law upon the statute books, but an effective force of men actually on the ground to patrol against fire. The man who puts out the most fires is the man who is looking for them, not the man who goes to a fire after it is under way. The system of voluntary fire wardens is good as far as it goes; but to make it really effective it must be combined with a force of trained men, whose first duty is fire patrol and who are sufficiently paid for their work.

STATE FORESTS.

In most States the area of forest land which will best serve the people of the State under state ownership and administration is much larger than the area now in state forests. In the extension of state forests, and in the better management of all state forest lands, the States face an immediate individual problem. Especially in the Lake States, vast areas of denuded lands, abandoned after logging destructive beyond all parallel, must be planted to trees long before they will even pay taxes.

EDUCATION.

The duty of teaching forest owners and users everywhere, how to conserve their forests, rests both with the Federal Government and with the States. The active cooperation of each State is essential. Many States present forest problems peculiar to themselves, which it is incumbent mainly upon each of them to solve. This can not be done without money, nor without trained men under a state forest organization.

THE NATION'S TASK.

The Federal Government, in its relation to the forest, faces two great tasks. The smaller is the conservation by use of forests which are already the property of the nation, or which it may acquire. The larger, in cooperation with the States, is to lead private owners to conserve by use four-fifths of the forests of the United States, which means to make forestry a household word and bring about universal household knowledge of its purpose, methods, and results. Forestry, through its relation to waterways and the wide shipment of its products, has special interstate relations.

ON PUBLIC FOREST LANDS.

In National Forests.—The forest lands which belong to the whole nation are in the National Forests, the Indian and military reservations, the national parks, and the unreserved public domain.

The National Forests conserve most of the water and one-third the timber of the West. This national heritage, whose resources so far as they can be measured in money are worth nearly two billions of dollars, is being rightly administered for the permanent use of the whole people.

At an average cost for protection of less than one-fifth of a cent per acre, the damage by fire on National Forests for the last three years has been, per million acres, about 3 per cent of that on private forest lands. In the same period the use of the National Forests by the people has more than doubled. In 1908 so great were the demands of the people's business that an average of only one-fifth of the time of the forest rangers could be given to fire patrol. This was the equivalent of all the time of one man for the patrol of 580,000 acres, an area half the size of the State of Delaware.

The quantity of mature timber taken from the National Forests each year could be increased several times with safety to the forest and with benefit to the people. But if the forest logged is to yield a good second crop, 20 to 30 cents must be spent for every thousand board feet harvested, in marking the trees to be cut, in supervising the logging, and in burning, as a safeguard against fire, the brush left upon the ground. If funds are provided to meet the growth of National Forest business, the safety of the forests will not be endangered nor will their increase year by year in national usefulness be checked. If these funds are withheld, either the National Forests must be inadequately protected or inadequately used. The least important of the great functions of the National Forests is to furnish revenues. It would be bad business management no less than shortsighted public policy to let any part of the property of the people lack the funds for operating expenses needed to make it yield its full return. But the use of the National Forests by the people, great as it is already, has only begun. It will increase as fast as adequate means are provided.

In national parks and Indian and military reservations.—National parks, Indian reservations, and military reservations contain a total of 13,000,000 acres of forest land, and more than 45,000,000,000 board feet of timber. Their location with reference to the National Forests makes cooperation in handling them an obvious and essential step.

The cooperation of the Department of Agriculture with the Department of the Interior in the handling of forest lands in Indian reservations is good in plan and purpose, and effective so far as funds are available; but for lack of money the larger area of forest lands in Indian reservations is neither being protected from fire nor conservatively used.

The forest lands in national parks and military reservations, as well as in Indian reservations, subject to the specific purposes for which they are held, should be administered under the policy and methods which obtain on National Forests, and adequate funds should be provided for the work.

It is no less the duty of the nation to take good care of all its forests than it is the duty of the private owner to conserve his forest holdings.

On forest lands of the unreserved public domain.—The timber and stone act has been in force thirty years. It has brought about for $30,000,000 the sale of timber worth at a very conservative estimate over $300,000,000. The number of entries is 88,000, and they cover a total of nearly 12,000,000 acres. The Federal Government, as the steward of the people, is losing yearly about $25,000,000 of the actual value of timber still being disposed of under this act, as well as the title to 1,500,000 acres of land which should be kept permanently as the property of the nation. The timber and stone act should be repealed, not only because of these facts, but also because it does not serve any useful public purpose. With its repeal there is urgent need for the sale of mature timber at its actual value and under proper restrictions, from unreserved public lands, both for the use of settlers and to supply the general need.

By consolidation of holdings.—Several western railroads own, as land grants, the odd-numbered sections in many National Forests. Legislation is urgently needed to permit the Federal Government to acquire these sections and other interior private holdings by exchanging for them timber inside the Forests or land of equal value outside, so far as practicable in compact bodies. Until such exchanges are made the protection and use of National Forests cut up by land grants or other large private holdings will continue to be expensive and difficult.

In the Appalachian forests.—Studies made at the direction of the congress show that the purchase for conservation by use of mountain forests in the southern Appalachians and in the White Mountains is an immediate national duty. Every acre in these proposed National Forests is on the watershed of navigable streams, most of which carry interstate commerce. These watersheds are already partly denuded and the process is going steadily and rapidly forward. The millions spent by the Government in dredging silt from the streams which flow from these mountain forests is insignificant in comparison with what must be spent unless the cause is dealt with, as well as the effect. Observation and record both show that the frequency and duration of floods in many of these streams is increasing. The flood damage in one year was more than it would have cost the Federal Government to buy in that year these eastern mountain forests, whose conservation is essential to the material welfare of the people of the East. The purchase by the Federal Government of all the mountain forest lands in the southern Appalachians and in the White Mountains is neither necessary nor advisable. The purchase of not more than 10 per cent of their total area upon the watersheds of important streams and the cooperation of the Federal Government in the conservation of adjacent forest lands owned by the State or privately would get adequate results.

Delay has entailed enormous preventable damage to forests and farms in the Appalachian and White Mountain regions, to their developed water powers, and to their vast water powers not yet developed. If delay continues, the damage will be irreparable.

COOPERATION WITH STATES.

The Federal Government has made forest studies in cooperation with ten States. These studies have aided in sound forest legislation, in a better handling of state forest lands, and in a better understanding by the people of the State of the need for forest conservation. This fruitful cooperation, in which the Federal Government bears, and rightly bears, one-half the cost, should be available to all other States. The money spent upon it is not merely an admirable national investment, but it maintains the principle of active cooperation between State and nation, vital to the right working out of our national forest problem.

EDUCATION.

The right use by American citizens of the forest and of timber will not be general until they learn how to practice forestry. For ten years the Department of Agriculture, by spreading broadcast the facts gained in its forest studies and by actual cooperation with the individual in the handling of his timber tract, his woodlot, his forest plantation, and his timber-treating plant, has carried forward a national campaign in education. One great result is the awakening of the American people to their national and individual need for forest conservation. The other is the conservative management of private forest lands of small area relatively, but of great value as object lessons.

Forestry has been given root and being in the great body of American citizenship. No country takes poorer care of its private forests than ours, and no nation has a more wholesome and enthusiastic public sentiment for the right use of the forest than our own. The basis already exists upon which to build a structure of forest conservation which will endure. But for this is needed the definite commitment of the Federal Government to its inherent duty of teaching the people how to care for their forests. Neither private enterprise unaided nor state enterprise unaided will achieve this result soon enough.

So far as practicable and within reasonable limits the forest studies made by the Department of Agriculture should be paid for by the industries and individuals whom they directly benefit. But the final responsibility for investigative work in forestry, which otherwise could not be done effectively or done soon, rests upon the Federal Government.

WHERE WE MIGHT STAND.

By reasonable thrift we can produce a constant timber supply beyond our present need, and with it conserve the usefulness of our streams for irrigation, water supply, navigation, and power.

Under right management our forests will yield over four times as much as now. We can reduce waste in the woods and in the mill at least one-third, with present as well as future profit. We can perpetuate the naval-stores industry. Preservative treatment will reduce by one-fifth the quantity of timber used in the water or in the ground. We can practically stop forest fires at a total yearly cost of one-fifth the value of the standing timber burned each year.

We shall suffer for timber to meet our needs until our forests have had time to grow again. But if we act vigorously and at once we shall escape permanent timber scarcity.

We take out of our forests each year three and a half times as much wood as they grow, partly because we waste more wood than any other nation. The saving of wood practicable in logging, in the mill, and in use has already been pointed out, but we fail to produce each year much more than the wood we need because we misuse the forest.

Against an average yearly growth of 12 cubic feet per acre in the United States, the forests in Germany, all of which are rightly handled, yield each year 48 cubic feet per acre, and their most common trees do not grow naturally as fast as ours. It is certain that the average annual yield of forests in this country can be made, through protection from fire and through conservative logging, much larger than that of forests in Germany.

Every owner of forest lands can stop fires and log conservatively, with immediate profit, as well as with permanent profit.

Most other countries have already learned that the forests which are not conserved will be used up, and they are taking care of what they have. We are among the last to learn it. We can profit by that knowledge if we will. But if we will it means action united, vigorous and prompt, State and nation.

SOURCES OF MATERIAL.

The estimates which this summary contains are based on all information about our forests possessed by the Federal Government and upon vigorous work for about six months in the special field of inquiry before the section of forests of the National Conservation Commission. One feature of the latter has been the sending out of more than 100,000 requests for information to forest owners and forest users throughout the United States.

The inventory made by the section of forests, simply because its scope has been wider than that of any other inventory of our forests, has shown still more clearly the urgent need for exact knowledge of just where we stand. We must have as a working basis a careful census of the kind, quality, and quantity of standing timber in the United States, of the condition of our forests, and of the wood we use for all important purposes. The nation can no more invite the best use of a national resource unless it knows essentially what that resource is than can the individual direct his own business successfully without taking careful stock of what he has.

The compilation of the data upon which this summary is based would have been impossible had it not been for the vigorous cooperation of state and federal agencies concerned, as well as of organizations representing national industries dependent wholly or mainly upon the forest. Had it not been for the cooperation of the Bureau of the Census, the voluminous and detailed computation necessary to the statement of the final results could not have been made in time; had it not been for the cooperation of the Bureau of Corporations we should not possess a trustworthy estimate of the aggregate amount of standing timber in the United States; and to the United States Geological Survey and to Mr. Bailey Willis, geologist and engineer, is due the scientific and comprehensive statement of fact as to the relation of the forests to the stream. These and many other agencies, federal, state, and private, have provided the material upon which this summary is based.

Both in the preparation of this summary and throughout the work preliminary to it I have been associated with Mr. R. S. Kellogg and Mr. W. T. Cox, of the Forest Service, who were designated for this task by the Forester. Their individual share in several important phases of the work greatly exceeds my own.

Through the compilation of material relating to forests and forestry, the following members of the Forest Service have aided greatly in the work: Messrs. W. Bradfield, H. S. Bristol, E. E. Carter, E. H. Clapp, T. C. Cleveland, jr., M. Cline, C. S. Chapman, S. T. Dana, E. H. Frothingham, W. B. Greeley, W. L. Hall, L. F. Hawley, G. M. Homans, C. Leavitt, L. Margolin, A. B. Patterson, A. S. Peck, J. G. Peters, A. C. Ringland, H. S. Sackett, W. F. Sherfesee, H. A. Smith, G. B. Sudworth, H. F. Weiss, P. P. Wells, E. A. Zeigler, and R. Zon.

Valuable assistance in the compilation of data has also been rendered by Prof. Henry S. Graves, director of the Yale Forest School, and a member of the National Conservation Commission; by Prof. Filibert Roth, in charge of instruction in forestry at the University of Michigan, and by Prof. F. R. Fairchild, assistant professor of economics in Yale University. Through general supervision of the methods for securing statistical data relating to forests and of the form of its final presentation, as well as in the aid throughout the work of his wide knowledge and experience, Mr. Henry Gannett has helped greatly to make the compilation what it is.

OVERTON W. PRICE,
Secretary, Section of Forests.

LANDS.

THE NATIONAL ESTATE.

The land area of the United States, excluding Alaska and the insular possessions, is about 3,000,000 square miles, or 1,920,000,000 acres. Of this area over half is arable, and a little less than half is occupied as farm land. About one-fourth is forest and one-eighth sparse wood land and cut-over land. Two-fifths is arid or semiarid, generally requiring irrigation; one twenty-fifth is swamp and overflow land requiring drainage. Most of the dry, wet, and sparsely wooded lands, with part of the forest area, is adapted to grazing.

About two-thirds of the land has passed into private holdings. Of the original 1,920,000,000 acres there remained July 1, 1908, 387,000,000 acres open to entry; nearly all of this is arid or otherwise unsuitable for settlement by families. There are also about 235,000,000 acres in national forests, national parks, and other lands reserved for public use.

USE AND ABUSE OF LANDS.

AGRICULTURAL INDUSTRIES.

In 1900 the farm lands comprised 838,591,774 acres; there were 5,737,372 farms, averaging 146.2 acres each. Of the farm lands, 414,419,487 acres, or 50 per cent of the farm area and 21.6 per cent of the total land area of the country, were improved. The value of the farms was $20,439,901,164, or 23 per cent of the wealth of the country. Of this value, 81.3 per cent was in lands and buildings, 15 per cent in live stock, and 3.7 per cent in implements and machinery.

The value of farm products in 1900 was $4,717,069,973, or $822 per farm, yielding a gross return of 23 per cent on the capital. Since 1900 agricultural production and investment have increased greatly, though exact figures are lacking.

In 1900, 10,381,765 persons, or 35.7 per cent of the wage-earners of the country, were engaged in agriculture. The proportion of the population so occupied is decreasing; in 1880 it was 48.3 per cent. The use of farm machinery is increasing rapidly.

We grow four-fifths of the corn crop, three-fifths of the cotton-crop, and one-fifth of the wheat crop of the world. We plant about 100,000,000 acres of corn, yielding an average of 25 bushels per acre; nearly 50,000,000 acres of wheat, averaging about 14 bushels; and 30,000,000 acres of cotton, yielding about 12,000,000 bales.

We had on January 1, 1908, 71,000,000 cattle, worth about $1,250,000,000; 56,000,000 swine, worth $339,000,000; and 54,000,000 sheep, worth $211,000,000. In 1900 we had $137,000,000 worth of poultry, which in 1889 produced 293,000,000 dozen eggs.

PRODUCTIVITY OF THE SOIL.

Over one-third of our wage-earners are engaged in agriculture, and all our people depend for their chief food supply on the productivity of the soil. The productivity is conveniently measured by crop yield.

Our crop yield per acre, according to the last three censuses, has been as follows:

Yield per acre.

		1899.	1889.	1879.
Barley	bushels..	26.8	24.3	22.0
Corn	do....	28.1	29.4	28.1
Oats	do....	21.9	28.6	25.3
Rye	do....	12.4	18.1	10.8
Wheat	do....	12.5	13.9	13.0
Rice	pounds..	807.0	797.0	632.0
Hay	tons..	1.4	1.3	1.1
Potatoes	bushels..	93.0	83.6	96.7

The yield estimated by the Bureau of Statistics of the Department of Agriculture for forty years, grouped by averaging ten-year periods (in order to eliminate the effect of exceptional years), is as follows:

Yield per acre.

		1867-1876.	1877-1886.	1887-1896.	1897-1906.
Corn	bushels..	26.2	21.1	24.0	25.4
Wheat	do....	12.0	12.5	12.7	13.8
Oats	do....	27.5	27.8	25.5	30.1
Barley	do....	22.8	22.4	22.7	25.5
Rye	do....	13.6	13.0	12.9	15.7
Buckwheat	do....	17.6	14.5	15.3	18.1
Hay	tons..	1.22	1.24	1.20	1.43
Potatoes	bushels..	90.0	82.0	75.0	86.0
Cotton	pounds..	181.0	170.0	172.0	191.0

Of these figures, those taken from the census are the more accurate, those taken from the Bureau of Statistics the more fairly representative of trend. They show that on the whole our crop yields are not decreasing; especially during the last ten years they have increased.

Grouped by States, the figures (appended among the accompanying papers) show for the older States an increase in yield throughout the forty years; and for the States in an early stage of settlement at the beginning of the record they show the influence of relatively large yields from virgin soil, followed first by a reduction and later by an increase of yield with improvement in agricultural methods.

The foregoing figures were supplemented by information obtained directly from every county in the United States. A schedule of inquiries was sent to a large number of farmers asking them whether in their judgment the fertility of the soil in their neighborhood was maintained, and, if so, whether by means of fertilizers or crop rotation, or both. The answers, to the number of about 30,000, are in accord with the foregoing figures. In the northeastern States little land is impoverished; in most counties none was reported. In the southeastern States the impoverishment is greater, though, except in West Virginia and Georgia, the proportion is not large. In the southern central States, excepting Alabama, Kentucky, and Tennessee, the proportion of impoverishment is large; while in the northern central States, excepting North Dakota, Nebraska, and Kansas, the proportion is small. In the western portion of the country there is a wide range, five States reporting no reduction in productivity, two reporting a small proportion, and four a considerable proportion. The total area of the counties comprising impoverished land is 307,730 square miles, or 10.3 per cent of the land area of the United States.

Local diminution in productivity is traceable to different causes:

1. The chief cause is erosion, including both leaching and washing of the soil. The annual loss due to this cause has been estimated at 7 to 10 per cent on upland farms, or some $500,000,000 yearly for the country. It can be largely or wholly prevented by proper cultivation and selection of crops.

2. A potent cause is continuous cropping, coupled with injudicious seeding. It can be counteracted by rotation of crops, selection of seed, and use of fertilizer.

3. A frequent cause of diminished yield is ravage of growing or ripening crops by insects, or sometimes by mammals. It can be remedied by the application of modern scientific methods.

That diminution in productivity is unnecessary is shown clearly by comparing our crop yields with those of long-settled and densely populated countries, in which the farming is more careful. The following figures show that our yields of oats, barley, and rye are much below, and our yield of wheat below half, those of Germany and the United Kingdom:

Average yield per acre, 1897–1906.

Country.	Wheat.	Oats.	Barley.	Rye.
United States	13.8	30.1	25.5	15.7
Germany	28.0	47.4	33.5	24.2
Austria	17.8	27.2	22.9	17.6
Hungary	17.6	30.[illegible]	22.7	17.3
France	19.8	27.8	22.4	16.7
United Kingdom	32.2	44.6	34.3	26.2

Both the American and European figures showing crop yield are in accord with fundamental principles. It is the natural law of soil to increase in fertility when properly treated. In a state of nature plants spread over rocky or earthy surfaces and combine with the action of the elements in disintegrating the material; the humus and other acids of plant growth and decay decompose the inorganic substances and dissolve the earth salts, rendering them available for plant food, and unless the slopes are excessive the material is in time reduced to a rich soil supporting an abundant flora. When such a soil is brought under cultivation it may by suitable treatment, including selection and rotation of crops, cultivation, drainage or irrigation, and other means, be made to continue increasing in richness and productivity; and in most cases the increase may be aided by judicious mulching and fertilizing.

The value of commercial fertilizer used in the United States is increasing; in 1880 it was $0.10, in 1890, $0.11, and in 1900, $0.13, per improved acre.

In conformity with these figures and principles, the largest yields of cereal crops are in the northeastern States, where intensive cultivation has been made necessary by dense population and consequent scarcity of land, and in the arid regions, where careful selection and cultivation have been induced by scarcity of water.

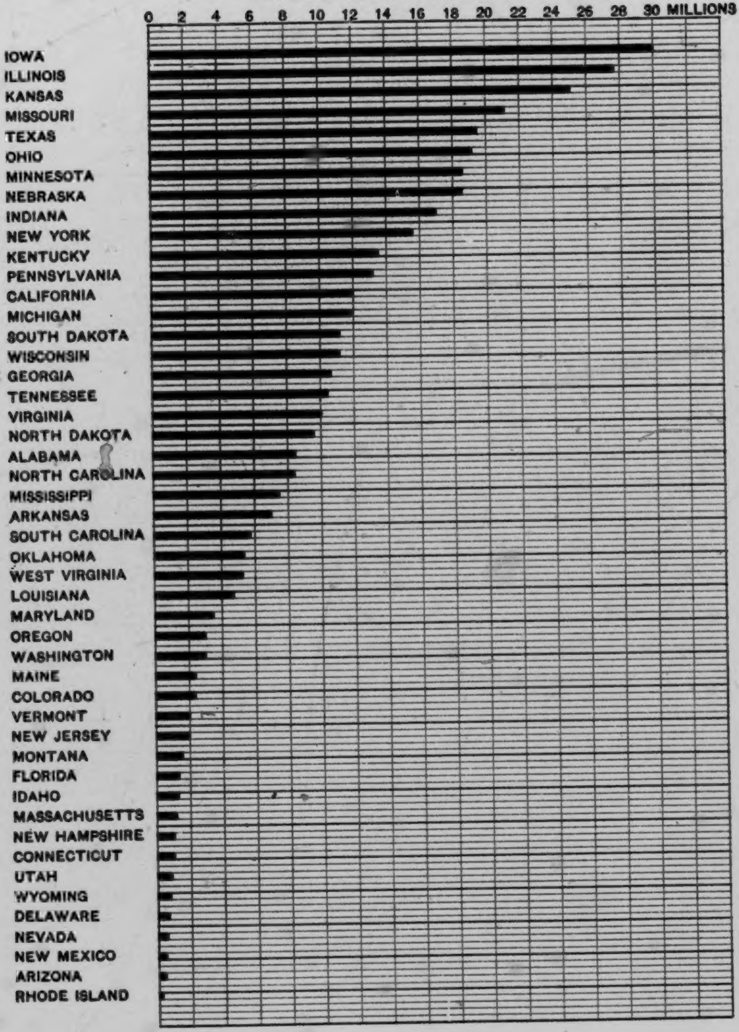
The figures for our crop yield since 1868 show a notable increase during some ten years past which can hardly be ascribed to the growth of intensive culture alone. It seems fair to credit this increase chiefly to the general improvement in farming due to the acquisition and diffusion of definite information by the Department of Agriculture, in conjunction with the experiment stations, state agricultural departments, agricultural colleges, and other scientific agencies. In connection with improved knowledge, the introduction of seeds and plants adapted to special conditions of soil and climate and the eradication of insect enemies have been important factors in maintaining and increasing production.

ABANDONED FARMS.

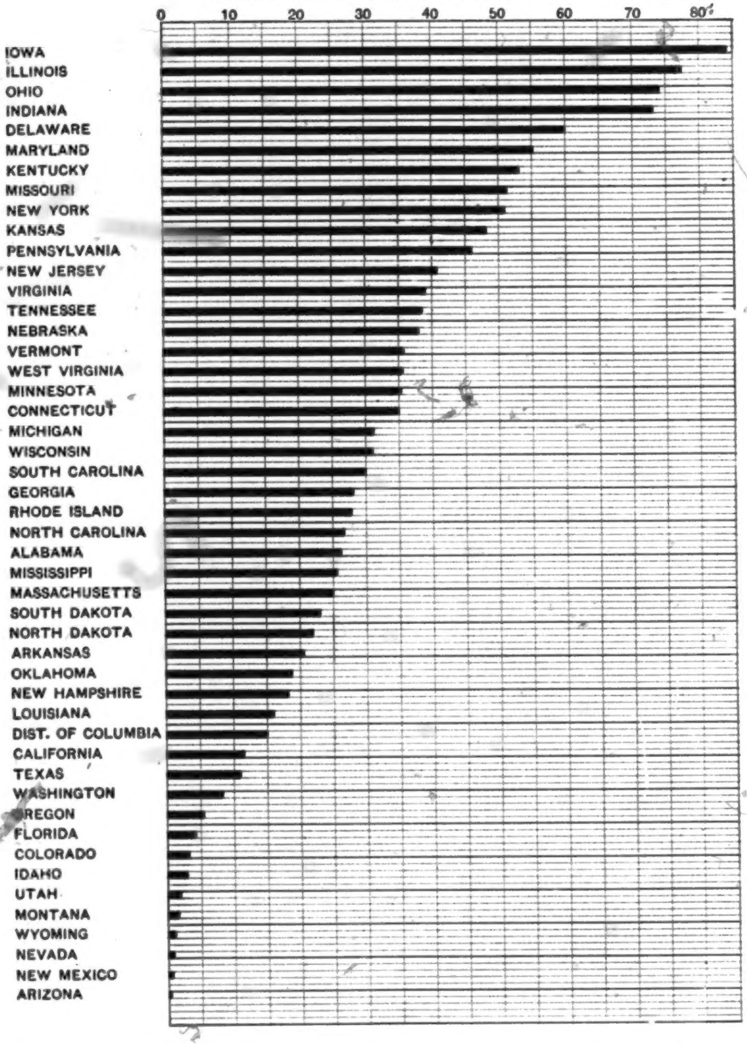
The schedule of inquiries addressed to the farmers in all the counties of the United States included questions as to the extent of abandoned farms. The 30,000 replies tabulated show that 16,597 square miles of farm land, or 0.6 per cent of the total area of the country, have been abandoned, and that 6,076 square miles, or 0.2 per cent of our territory, were, after abandonment, devastated by soil erosion.

Half of the abandoned lands are in southeastern United States. A few years ago abandoned farms were common in New England; of late they are largely reoccupied and rendered productive mainly by Italian or French-Canadian farmers.

Neither the abandonment of farms nor the local impoverishment of fields can justly be ascribed to deterioration of the soil; like our low crop yields, they are due to general industrial and economic conditions, which are not only susceptible of control, but are steadily changing with increasing density of population. In most rural districts, land is cheap and abundant, and labor costly; and the chief efforts of farmers are directed toward getting the largest returns per unit of labor rather than per unit of land. Especially in newly settled areas, farming is hasty and careless; the same crops are grown year after year until they run out; no attention is given to soil wash or to the maintenance of friability by drainage or otherwise, and little to the selection of seed; while fertilizing and mulching are neglected. In its legitimate use, the soil is abused to the limit. The condition is due partly to ignorance and cupidity, though chiefly to inadequate transportation facilities. With increasing population, markets are brought nearer to the farms, and traffic is facilitated; then, as in some of the northeastern and southern States, intensive or at least careful cultivation is adopted, and generally within a few seasons the productivity is raised even above that of the virgin soil.



ACREAGE OF IMPROVED LAND IN 1900.



PERCENTAGE OF IMPROVED LAND TO TOTAL AREA.

In districts liable to extensive soil erosion, the abandonment of fields is disastrous; in some cases the old-field erosion not only removes the soil proper, but carries away the subsoil and even the superficial deposits, exposing bare rocks or intractable formations over which soils naturally redevelop with extreme slowness, and can not be extended artificially except at large cost. The fact that over 6,076 square miles, or 3,888,640 acres, of our abandoned fields have been destroyed in this way is appalling. Not only would the area form nearly 100,000 farms capable of sustaining a population exceeding that of any one of our 12 least populous States, but each gully starts others in such manner as continually to extend the devastation. The evil should be remedied without delay. Communities and States should be awakened to the sacrifice of public interest through old-field erosion. First in connection with abandoned fields, and progressively in cultivated fields, soil wash should be considered a public nuisance, and the holder of the land on which it is permitted to occur should be held liable for resulting damages to neighboring lands and streams.

NECESSITY FOR INCREASING CROPS.

The population of the United States in 1900 was 76,303,387; probably it will double by the middle and triple before the end of the present century. In view of this growth, the question of food supply assumes the highest importance. How shall the greatly augmented demand for foodstuffs be met? Can sufficient food be obtained from our own soil or will it become necessary to import, and, if we import, how shall we find the means?

Hitherto we have not only supplied ourselves with foodstuffs, but have had a small (and decreasing) surplus for export. They were in the last census year produced from 647,666 square miles of farm land, or 21.6 per cent of the total land area of the country. To supply the needs of our prospective population at the end of the present century by merely increasing the area of farm land would require that nearly two-thirds of our entire area be under cultivation—or far more than our aggregate arable lands, since arid districts, rugged country, and mountainous areas too elevated to produce crops form half the area of the United States. Even during recent decades the increase in cultivated land has not kept pace with that of population. Between 1890 and 1900 the population increased at the rate of 20.7 per cent, while the area of improved land increased only 15.9 per cent; and, as cultivation crowds on cultivability, the difference must widen.

Aside from the importation of foodstuffs, but one feasible way of meeting our growing demand appears—i. e., to increase our crop yields. That this is not only feasible but entirely practicable is shown by the larger yields of long-settled countries, by the reclamation of abandoned farms with increasing local population, by the general increase in our crop yield during the last decade, and by the natural tendency of soils to increase in fertility when properly treated.

There is some diversity of opinion among experts as to the trend of our crop yield and as to the reasons for increase or decrease. Early in 1908 there was a decided opinion (expressed at the governors' conference and elsewhere) that our yield began to decline soon after the breaking up of the virgin soil and has continued to decline throughout the country, but the exhaustive figures brought together, largely by Victor H. Olmsted, Chief of the Bureau of Statistics, Department of Agriculture, and appended among the accompanying papers, render it fairly clear that the minimum is already past and that the normal increase in productivity has begun. Thus far the increase is slight and does not at all keep pace with the growth in population. The conditions affecting productivity are discussed by Professor Whitney, Chief of the Bureau of Soils; Doctor Galloway, Chief of the Bureau of Plant Industry, and other specialists in accompanying papers.

DECLINE IN EXPORTS OF FOODSTUFFS.

During the last ten years our exports of foodstuffs have diminished relatively as compared with the preceding decade, suggesting that we are consuming more and more of our product. This may represent a temporary oscillation, like several in the past; it may be due in part to inadequate transportation facilities, such as prevented the satisfactory movement of the harvests of 1906; but it probably marks the beginning of the end of our exportation of foodstuffs.

The proportion of our wheat crop exported yearly as wheat and flour since 1871 has ranged about from 8 to over 41 per cent; the fluctuations being traceable to variations in size of crop coupled with the increasing home demand. The home consumption per capita since 1871 has ranged from 3.44 to 7.07 bushels, averaging about 5 bushels, with a tendency to increase. The percentages of exports to total crops, averaged by groups of years, have been: 1871–1877, 23.3 per cent; 1879–1887, 31.17 per cent; 1888–1897, 30.45 per cent; and 1898–1907, 27.18 per cent. From the first to the second of these groups there was a decided increase in the proportion of exports; the period was one of rapid extension of settlement in wheat-growing districts. In the second and third groups the proportion was practically the same, though the extension of settlement continued. The fourth group shows a decline, and the last four years a great decline, not only in the proportion but in the absolute volume of exports.

Exports of other cereals are too small and too irregular in amount for useful discussion.

The amount of meat produced annually is not recorded, but the number and value of live stock are estimated annually by the Department of Agriculture, while the live stock and meat exports are recorded. When the values of such exports are compared with those of live stock, the figures show a marked decline in foreign shipments during the last decade. The figures are in accord with those for wheat and flour.

Both classes of exports seem to show that the country is past the period of maximum proportional exportation of foodstuffs, and that hereafter the proportion will continue to decrease as the demands of our industrial population gain on our agricultural production. This conclusion is fortified by the values of our exports of all crude foodstuffs and food animals, which has fallen from $305,000,000 in 1898 (the largest in our history) to $167,000,000 in 1907, with an average of $151,000,000 for the six years 1902–1907, inclusive.

The record of exports is consistent with the fact that in no case is the production of our food crops increasing so rapidly as our population. In the decade between 1890 and 1900 the increase of population was 20.7 per cent; the increase in production was 19 per cent for corn, 15 per cent for wheat, and 7 per cent for oats, potatoes making no appreciable gain. The increase in live stock is more marked, though it averages less than the gain in population; during the same decade cattle increased 23 per cent and sheep 24 per cent, while swine increased only 5 per cent.

WASTES DUE TO NOXIOUS INSECTS AND MAMMALS.

Aside from careless or ignorant farming and such hostile climatic conditions as storms and droughts, the most serious enemies to crops are noxious insects and mammals.

The chief insect enemies of the grains are the corn-root worm, the bollworm, the chinch bug, the Hessian fly, plant lice, grasshoppers, cutworms, and army worms. The worst enemy of cotton is the boll weevil. Fruits are injured chiefly by the codling moth and the San Jose scale. The Bureau of Entomology estimates that the annual damage by noxious insects to growing crops, fruit trees, and grain in storage is no less than $659,000,000. This total includes the cost of preventive measures which greatly reduce the aggregate loss.

The average yearly loss to animal products from flies, ticks, and other insects is estimated at $267,000,000. This does not include the enormous loss of human life and the cost of disease due to house flies, mosquitoes, fleas, and other germ-carrying insects—a loss much greater than that suffered by the live stock and their products.

The Biological Survey estimates that the damage to live stock and crops by wolves, rats, mice, and other mammals averages over $100,000,000 yearly. This figure also includes the cost of preventive measures; without them the losses would be much greater. Birds generally are beneficial as destroyers of noxious insects and mammals.

While the figures are staggering in the aggregate, they represent careful and frequently repeated estimates by conservative specialists, and in each case they are in accord with the common observation of intelligent farmers and other citizens. They must be regarded as trustworthy and as representing an enormous preventable waste.

LOSSES OF LIVE STOCK BY DISEASE.

The appended statement by the Bureau of Statistics of the Department of Agriculture shows that the average loss by disease during the past five years was: Among horses, 1.8 per cent; among cattle, 2 per cent; among sheep, 2.2 per cent, and among swine, 5.1 per cent. The aggregate annual loss averaged $93,000,000.

The most prevalent disease among cattle and swine is tuberculosis; it is estimated that at least 1 per cent of beef cattle, 10 per cent of dairy kine, and 2 per cent of swine are affected. Sheep and cattle suffer seriously from scabies, while hog cholera is prevalent among swine. Texas fever among cattle (transmitted by a tick) is a destructive disease, causing a direct annual loss estimated at $40,000,000. All these diseases are remediable, and some or all may be eradicable.

The total annual losses to the agriculture of the country, including live stock, animal products, and grain in storage, from insects, mammals, and disease is estimated at $1,142,000,000, or one-sixth of the total production.

WILD GAME AND FUR-BEARING ANIMALS.

Our wild game and fur-bearing animals have been largely exterminated. One of the most painful chapters in the period of our wanton waste is the destruction of wild game. Everyone knows the story of the passing of the buffalo and of the fur seal; not so well known is the recent history of the moose, caribou, deer, elk, antelope, mountain sheep, and mountain goat. A generation ago most of these abounded on the western plains and mountains; now they are rarely seen. Fortunately, before their complete extermination, most of the States and the United States began their protection, and under wise laws, generally well enforced, many of the game animals are now increasing.

With protection the game animals, like many fish and game birds, are becoming a source of large benefit to the country, as is well shown in the appended statement by Dr. C. Hart Merriam, Chief of the Biological Survey.

With game birds the story is much the same—wanton destruction until the number was greatly reduced, followed in recent years by wise protection, allowing the remnant to survive and even to increase.

Our game animals and birds supply food, skins, furs, and feathers to the annual value of several million dollars, and the amount is increasing.

FISH.

Our fish supply is now largely dependent on artificial propagation. The annual value of the fisheries of the United States is $57,000,000; the products form an important element of our food supply. Salmon, trout, shad, lobsters, and other important varieties are maintained almost exclusively by propagation and restocking.

The production and propagation of fish and the restocking of streams and lakes are seriously retarded by conflicting laws or absence of laws in the different States; in some cases, as in Columbia River, the diversity of state laws is seriously inimical to the maintenance of the fisheries. It is of the utmost importance that the States should cooperate among each other and with the Federal Government for the protection and development of the fish and fisheries of interstate streams and lakes.

THE OPEN RANGE.

The area of open range on the Great Plains, in the Rocky Mountains and in the Great Basin exceeds 300,000,000 acres. The climate ranges from temperate to hot and from semiarid to desert. The pasturage was originally variable in quality, though generally sparse. The greater part was excessively overstocked soon after settlement began, and in some districts the pasturage was virtually destroyed. On the whole the range is in bad condition and of greatly reduced value; the portions occupied by sheep are especially poor, owing to overstocking and trampling.

It is clear that the public range is greatly deteriorated and that the deterioration is still in progress. It is equally clear that it might be restored by proper regulation of grazing, coupled in some cases with complete protection for terms of years, perhaps with some reseeding. The requisite control can be exercised only by the owner of the range, the Federal Government. Experts are of opinion that in most cases restoration can best be accomplished by leasing to stock owners for considerable periods, and allowing them to fence their holdings; for under such a system the stockmen would be interested in maintaining and improving the pasturage, while the governmental cooperation would afford protection from lawless invasion by competitors. The same system would alleviate the shocking cruelty of the range, under which stock have been starved and frozen and slaughtered by thousands through the shortsight and cupidity of stockmen having no interest in range or State beyond that of skinning it to the utmost for immediate profit.

SWAMP AND OVERFLOW LANDS.

The area of swamp and overflow lands is estimated at 75,000,000 or 80,000,000 acres, or about 4 per cent of our territory. The swamp-land area is capable of fairly exact delimitation and has been generally mapped, while the land subject to overflow can not be sharply defined, and the statements of area are merely approximate.

The swamp-land act of 1850 granted to the States then in existence all the lands within their limits classed by the surveyors of the General Land Office as swamp. Under this act 65,582,503 acres have been patented to the States; while 1,307,700 acres, nearly all in Minnesota, remain in public possession.

Of the swamp lands patented to the States, 60,142,003 acres have been conveyed to individuals or companies, leaving in possession of the States 5,440,500 acres.

In the States not affected by the swamp-land act the greater part of the wet lands have apparently passed into private ownership, except in those admitted since 1850, to which it has been judicially decided that the act does not apply and in which the swamps are inconsiderable, the United States still retains the greater share.

The cost of reclaiming swamp and overflow lands varies widely. Generally it is estimated that the value of the reclaimed lands is double or triple the original value plus the cost of reclamation. Practically all the wet lands of the country can be reclaimed at profit, and it is estimated that they would form homes for a population of 10,000,000. The chief obstacle is lack of coordination; generally the work can not be done by settlers or pioneer families, or even by communities, since reclamation projects are necessarily extensive and costly, and in many cases cross state boundaries. The plan of the Inland Waterways Commission contemplates reclamation of swamps and requisite protection of overflow lands as a part of a general system of improvement designed for the control and utilization of the waters. The plan is feasible, and when carried out will doubtless benefit the country greatly through increasing the capacity for population and production and converting the present wastes into sources of wealth.

The reclamation of swamp and overflow lands is in progress in several sections, usually under state appropriations, sometimes by county authorities or drainage districts. Details appear in appended papers prepared in the Geological Survey and in the Office of Experiment Stations.

A large incidental benefit arising from the drainage of swamp and overflow lands is the reduction of malarial and other disorders and the increase in viability and efficiency of our population. This aspect of the reclamation is discussed by Prof. Irving Fisher in the appended paper on "Conservation of life and health."

INCREASE IN PRIVATE HOLDINGS.

About five-sixths of the land area of the United States has passed into private holdings. In the early history of the country there were extensive land grants, most of which were gradually subdivided with settlement.

The land laws of the United States were framed with a view to the settlement of the country and the making of homes, and during the greater part of our history this policy was pursued by both nation and settlers. During recent decades, especially since forests, minerals, waters, and in some cases pasturage, came to be recognized as valuable in themselves apart from the land surface, individuals and corporations have frequently taken advantage of opportunities to acquire large holdings of land in order to gain control of the associated resources, and in many instances energetic farmers and other owners have acquired large tracts of land for agricultural purposes. The question of land holding is fundamental to the policy and practice of our Government, and it would seem of the greatest importance to ascertain whether the current tendency is toward large holdings with consequent landlordism, or toward smaller subdivisions and freehold homesteads. Naturally the tendency can be ascertained only through the facts of private ownership in the several sections of the country.

With a view to gaining the best information available, a schedule of inquiries was sent out in large numbers to selected farmers residing in every county of the United States; and, while the inquiries were designed to elicit information on other subjects, several were directed to the question of increase or decrease in area of holdings. When the 30,000 useful replies, averaging about 10 from each county, were classified by counties, it was found to be the opinion of the correspondents that in 48 per cent of our area the size of farm holdings is increasing, and that in the remaining 52 per cent the size is either decreasing or there is no appreciable change.

The States in which the majority of the farm holdings were reported as increasing are mainly those west of the Mississippi, with a few farther eastward. Thus it appears that the tendency toward increase is greatest in newly settled regions, and that in the long-settled sections the average holdings either remain unchanged or tend to decrease.

In the holdings of mineral lands there is a marked tendency toward increase in area. This is decided in the case of iron lands, and is of course connected with the greater economy of large operations in mining, transporting, smelting, and manufacturing. In oil lands the tendency toward consolidation is apparently slight; in coal lands and those containing other minerals the tendency toward increase is intermediate.

In timber lands the tendency toward consolidation is strong, and has gone far toward placing control of such lands in a few hands. It appears that the monopolization is partly in the interests of economy in logging, milling, and manufacturing, but chiefly speculative.

On the whole there is a distinct tendency toward increase in size of holdings, chiefly in nonagricultural lands, but it is not so decided as to indicate that the homestead policy is unsatisfactory to the American people or out of accord with public welfare.

THE PUBLIC LANDS.

DATA AND POLICY.

The inquiry concerning the public lands involved a continuation of the work of the Public Lands Commission appointed by the President October 22, 1903. The information compiled by that commission has been utilized with such amplification or modification as seems justified by the added experience of three years, and the further knowledge obtained by the government bureaus directly in touch with public-land questions, viz., the General Land Office, the Geological Survey, the Reclamation Service, the Forest Service, and the Indian Office.

So far as the lands owned by the United States are concerned, the effort has been to determine the true relation of the public-land laws, as they are and as they should be, to the fundamental conditions affecting the permanent efficiency of the people. The former is mainly founded on the following premises:

1. The nation should hold in its possesion and maintain in efficient condition those areas which are less valuable for agricultural use or home making than for conserving unique natural beauty and wonders, the water supply, and the timber.

2. The resources still belonging directly to the nation which must necessarily be diminished and finally destroyed by use, should be exploited and used in a way to return the greatest benefit in the long run to the greatest number, the essential caution being to prevent waste, and, without prohibiting or hindering economical development, to prevent such monopoly as might artificially increase the cost of the resources to the people beyond what would bring to the exploiter a full reasonable profit and no more.

3. When the land itself, independent of the minerals under its surface, is more valuable for agricultural use than for permanent dedication to the public use, it should be conveyed in such areas as will furnish a reasonable living to an average family to those who will actually make homes on it, and to no others.

4. Pending the disposal of any public land by reservation for public use, or by appropriation under the public-land laws, it should be protected from deterioration and so administered as to serve the best interests of all the people.

These conditions can not be met certainly without a classification of the public lands.

LAND DISPOSAL.

On July 1, 1908, there were about 755,000,000 acres of public lands neither appropriated nor reserved, including approximately 368,000,000 acres in Alaska and 387,000,000 acres in mainland United States. Between June 30, 1904, and June 30, 1908, the unappropriated and unreserved area of mainland United States was reduced from 473,836,402 acres to 386,873,787 acres.

The problem of dealing with the remaining public land is the more difficult and important because the choice lands for farming are gone. There is great pressure for disposing of the remaining public land in larger homesteads on the plea that, since it is of less efficiency, a family will need more to make a reasonably comfortable living. Yet, although the highest number of final homestead entries—37,568, covering 5,241,120.76 acres—was made in 1901, the entries for the year ending June 30, 1908, were 29,636, covering 4,242,710.59 acres, which number was exceeded only in the years 1901 and 1902. The people themselves, therefore, are showing concretely that the inducement to enter public land need not now be increased, since the desire to secure a homestead of 160 acres is still strong enough to increase rather than diminish the number of entries.

In other respects the public-land laws, as they exist to-day, do not, either in their substance or in the limited opportunities for strictly administering them, furnish the necessary protection to the people's interest in the public lands. Changes are necessary, not only because the present laws are not suited to existing conditions, but also partly because these laws, as originally drawn, contemplated conditions and needs which have been greatly modified by unforeseen political, social, and economic conditions, and by decisions of the Land Department and of the courts which were not foreseen by the lawmakers. This will be noted in connection with each law considered. The conditions are described in an appended paper by Mr. H. H. Schwartz, chief of special agents, General Land Office.

LAND CLASSIFICATION.

Because of the diversified condition of the public lands there is need to know, for reasonably small areas, whether the surface is chiefly valuable for agricultural purposes, for timber, or for grazing purposes. As to what is beneath the surface, we need to know whether the land is mineral or nonmineral. The mineral lands must be subdivided into various classes, according to the kind of mineral. With reference to the surface, the main classification must be into timber, grazing, and agricultural land. Having once admitted that the surface of all lands should, except in so far as it is actually needed for exploiting the minerals beneath it, be acquired by those who will best use it for the public welfare in lumbering, grazing, or agriculture, and that the minerals themselves should be exploited in reasonably large but limited areas by those who have the knowledge, skill, and capital, it follows irresistibly that no scheme of public-land laws can be thoroughly effective for the purposes for which they are enacted, unless they provide for or allow an authoritative classification of the lands. The power to classify should, as a matter of course, carry with it the power to reclassify when changing conditions or newly discovered evidence show that the lands involved should be differently classified.

The cost of classification will necessarily be considerable, but it will be possible, by prompt and skillful classification, to save the Government amounts many times greater than the cost, without requiring more than reasonable prices for any lands and none for those disposed of for home making. Scientific classification would ultimately fix with certainty, according to the productive value of the surface, a reasonable home-making area for each class of agricultural land, and thus solve that problem without mistake or friction.

A discussion of the question of classification by Hon. Fred Dennett, Commissioner of the General Land Office, is appended.

TIMBER AND STONE ACT.

The timber and stone act of June 3, 1878, was passed in order to give the home maker a timber lot to be used in conjunction with his homestead. This is evidenced by the debates in Congress at the time of the passage of the act; also by the provision that the applicant to purchase must declare "that he does not apply to purchase the same on speculation, but in good faith to appropriate it to his own exclusive use and benefit." As the timber of the country was cut off and destroyed by reckless lumbering and forest fires, the value of timber land increased with great rapidity. The farsighted lumber operators foresaw that the value of the fine timber would increase for some time in geometrical progression. They therefore followed a natural business instinct, and began to take advantage of the timber and stone act to acquire the best forests in the West. They employed cruisers, who went over and determined the value of the various legal subdivisions containing heavy stands of timber. They allowed the public to know that they would purchase certain timber land from any who might enter it under the timber and stone act. In some instances they imported shiploads and carloads of their employees and other persons, furnishing them with the necessary funds to buy. These persons entered valuable contiguous quarter sections, and transferred them wholesale to their principals. A specific instance is that in Modoc County, Cal., where more than 85 per cent of about 25,000 acres of timber land entered in one calendar year was transferred before May 1, as was shown by a search in the recorder's office of the county. Over 14,000 acres of this went to one man, and the bulk of the rest to three others.

It is clear that the timber and stone act does not fulfill the purpose for which it was passed, and that it should be repealed.

COMMUTATION CLAUSE OF THE HOMESTEAD ACT.

The Commission on the Public Lands, in its report and appendix of February 13, 1905, shows with great clearness that the commutation provisions of the homestead act open the door to immense possibilities for fraud. The illegal acquisition at $1.25 per acre of land worth ten or even a hundred times that sum easily follows the opportunity. Quarter sections covered with heavy timber are often worth from $10,000 to $20,000 or more; and it is well worth a man's time and expense to build a small shack and actually live on such land for fourteen months in order to acquire it. To do certain small acts of improvement during this time is a matter of small moment to the mala fide settler. The net gain, if the entryman sells the land for anywhere near its value at the end of the time, is often at the rate of several thousand dollars per year. Even so, there is strong reason to believe that most of those who acquire lands fradulently under the commutation clause do not profit to any great extent, but are paid only a small wage for giving their time and homestead right to others who wish to acquire the valuable land in defiance of law.

The commutation provisions of the homestead act should be absolutely repealed, and anybody wishing to obtain land from the United States, free of cost, should show the bona fides of his intent to make it his home by living there the full five years required by the homestead act.

An alternative recommendation would be that after three years bona fide and continuous residence at home on the land, an entryman may commute it if his improvements and cultivation are so ample that they show beyond a doubt that he is taking the land for farming and not for other purposes.

It is recommended strongly that no commutation should be allowed for land covered with valuable timber unless sufficient clearing and successful cultivation have been made to remove any doubt as to the intent of the entryman; also that grazing only should not be allowed as sufficient cultivation of land to warrant commutation.

The grounds for these recommendations are set forth by Mr. Schwartz, chief of special agents, General Land Office, in an appended paper.

DRY-FARMING LANDS.

The principle that land capable of agriculture should be given to the home maker only in such areas as will by farming maintain an average family in reasonable comfort is commended. In certain localities dry farming would be successful on land which does not contain water for drinking and other domestic use. In these cases the home can not be maintained on the land itself, and it would seem wise to allow it to be established at some place near enough to serve as the base of operations for improving and actually cultivating the land entered; but successful production of crops and a continuous home in the neighborhood should be required.

DESERT-LAND LAW.

The Public Lands Commission, in its reports of 1904 and 1905, showed that the practical working of the desert-land law is lamentable. The small force of special agents and inspectors at the command of the Land Department and the heavy burden of routine work devolving upon them in the way of hearings has made it impossible thus far to investigate by government agents whether the reclamation work and improvements claimed have actually been made. The fact that the land can be obtained in larger quantities than under any other agricultural law offers an inducement to fraud, and there are usually others interested, by reason of being like circumstanced, who are available for manufacturing proof on the record when the facts upon the ground are absurdly deficient.

The desert-land law might possibly be repealed in toto without harm to the best interests of the people in its public-land property. Such a repeal would not make it impossible for a man to get possession of land desert in character by living on and reclaiming it under the homestead law, but there are those who claim that the requirement of residence is incompatible with the desert character of the land, and that a home can not be established or maintained until after the land is reclaimed. In deference to the view that such land would remain unreclaimed if it were not for a law similar to the desert-land act, it is recommended (1) that entry be limited to 160 acres; (2) that residence to the exclusion of a home elsewhere must be established by the entryman within three years after the original entry; (3) that the entryman must prove that he has actually resided upon the land for two full years immediately preceding the date of final proof; (4) that final proof must be made not less than four nor more than seven years after the original entry; (5) that final proof must show that at least one-fourth of the land has been successfully cultivated to crops by irrigation for two successive seasons; (6) that no commutation be allowed; and (7) that there shall be no charge to entrymen except the fees required in homestead cases.

The object of these modifications is to accomplish the purpose of the present desert-land act, namely, an actual reclamation of land, and at the same time maintain the best features of the homestead law. The matter is discussed in an appended paper by Mr. W. B. Pugh, of the General Land Office.

GRAZING LAND.

There are more than 300,000,000 acres of public land, of which the surface can not at present be successfully farmed. This is an area more than ten times as large as Ohio. Nearly all this land can be used for grazing. Under existing law any person can at any time take any number of any kind of live stock upon any part of this public range. To obstruct or try to prevent him is a criminal offense. Under these circumstances nobody has either the power or inclination to prevent overgrazing. The result is that the range is overstocked, and the forage is rapidly deteriorating both in quantity and quality. As the grazing grows poorer, there is no tendency to diminish the overstocking. Each stockman wants his neighbor to do that. Meantime changed conditions of transportation and market make the raising of sheep more profitable than cattle growing, with the result that sheepmen have for years been crowding on the already overstocked range, and their sheep have hastened the destruction of the forage plants. Contentious strife, destruction of property, breach of the law, and even murder, have followed.

It is recomended that the surface of the remaining public domain be dedicated by law to grazing purposes with reasonable regulation, (1) to insure that the land may be entered at all times under the homestead laws for the bona fide purpose of home making, (2) to protect the rights of those who already have stock on the public domain, (3) to allow fencing for individual or community use, (4) to impose such conditions in the permits as shall prevent overstocking and gradually bring the range back to its full forage capacity, and (5) to make sure that the distribution and use of grazing rights shall be equitable and shall carry with it the indispensable element of business certainty concerning duration and conditions of the permit.

Discussion of the grazing lands appears in appended papers by Mr. A. F. Potter, of the Forest Service, and by Mr. A. D. Melvin, of the Bureau of Animal Industry.

RIGHTS ANALOGOUS TO SCRIP.

There are various "location, selection, and scrip" rights outstanding against the public domain. These are rarely used for the making of homes. Some of them have been in existence over half a century, and are yet unused. They originally were supposed to have a value of only $1.25 per acre, but the growth of the country and changed conditions make them worth now from $10 to $20 per acre. These rights are a source of never-ending difficulty and embarrassment in the administration of the public land. It is strongly recommended that Congress pass a law for their retirement which will fix a reasonable limit of time in which they may be located, or selections made as the case may be, after which the rights shall be redeemable in cash. An appended paper by Mr. S. W. Williams, of the General Land Office, gives details.

SEPARATION OF RIGHTS.

In 1906 the Interior Department discovered that vast areas of coal lands were being taken up with or without knowledge of their coal character under the various nonmineral laws. President Roosevelt, to prevent this improper and wasteful disposal of coal, withdrew over 68,000,000 acres, all or part of which in each township involved were known by the Geological Survey to contain coal. It is not lawful to take coal land under the homestead law. Therefore, as the law stands to-day, more than 50,000,000 acres, much of the surface of which is valuable for farm homes, is withheld from the homesteader, and unless the law is changed that fundamental principle of national efficiency, which demands that the agricultural lands be placed free of charge in the hands of agricultural home makers, can not be applied to this land, because the surface must eventually, by purchase of coal and surface together, under the coal-land laws, fall into the hands not of homesteaders, but of miners. On the other hand, President Roosevelt was so convinced that the agricultural land laws should not be used for the purpose of acquiring coal lands that he has, by withdrawal and classification, dedicated the above-mentioned vast area of coal entry, but, to protect the homesteader, has urged Congress to amend the public-land law so that a homesteader can get freely what he ought to have and the miner get only full opportunity to mine his coal without holding farming land away from agricultural home makers, either at prohibitive prices or as the foundation for tenant farming. The accompanying paper by Hon. Fred Dennett, Commissioner of the General Land Office, discusses the matter fully.

MINERAL LANDS.

There is no way to use both the surface and the resources beneath it to their best advantage in the long run for the largest number except by disposing of them separately. Our present knowledge of the needs of the country does not warrant recommendation that the precious metals be disposed of otherwise than by sale, either with or without the surface; but the following recommendations seem fully justified:

(1) That the area of lands containing precious metals entered by any one person or association should be definitely limited, and that entries made on reserved lands should give title to only so much of the surface as may be found reasonably necessary for exploitation of the minerals. This is in line with the fundamental principles of preventing monopoly and devoting the surface of the land to its highest use. The limit should not be so low, however, that it will interfere with the economical exploitation of the resources as viewed from the business standpoint.

(2) That all locations must be filed at the local land offices within six months of their initiation. This is absolutely demanded by the need for the Land Department to know when a claim is initiated against the public land.

(3) That a location be considered abandoned unless followed by final proof and cash entry within a reasonable limit of time. The reason for this is that right to mineral land should go only to bona fide miners, not to speculators, and that a locator should make good his claim or get out of the way reasonably soon.

The reasons for these recommendations are stated in an appended paper by Mr. E. C. Finney, of the General Land Office.

COAL LANDS.

With regard to coal lands, it is clear that the coal still owned by the people, when classified by the Geological Survey, should be disposed of under leases only. The present coal-land law makes it impossible for any one association of persons to obtain legally more than 320 acres. This is not sufficient for the conduct of an economical mining business. The area which may be leased should be increased materially. It is recommended briefly as follows: (1) That in this and in all changes of the law valid existing rights should be protected; (2) that, except for rights already initiated, no patents or final certificates issue for any public lands, except with a specific reservation of the coal; (3) that the patents also reserve specifically a reasonable provision that the miner may, with compensation to the surface owner, acquire such part of the surface as may be needed in producing the coal; (4) that provision be made for reasonable damages if mining operations injure any property of the owner of the surface; (5) that the Secretary of the Interior shall lease the public coal lands under such regulations as he may deem wise for the protection of the public interest, in such reasonably limited areas, with such charges, and for such reasonable periods as may be fixed and made certain in each lease; and (6) that, at the discretion of the Government, the lease may be renewed or the lessee compensated for his improvements after termination of the lease period by a method fixed in each lease.

Details appear in appended papers by Mr. T. J. Butler, of the General Land Office.

OIL, GAS, AND OTHER NONMETALLIC MINERAL LANDS.

Oil, gas, and other nonmetallic mineral lands can at this time be acquired under the placer mining law, which means that any person can get possession of as much land containing such minerals as he can discover and locate, even though it were millions of acres, and that he need not buy from the Government unless and until he desires. When this is compared with the restriction of coal land to 320 acres, the ill logic of both laws is evident. It is recommended that these minerals should be disposed of under practically the same conditions as recommended above for coal.

RIGHTS OF WAY.

No public-land laws fall so far short of being right and equitable as those which provide for rights of way. In many instances the most important of these laws fail to give that certainty to the grantees or permittees which is absolutely necessary for business security. In other instances they give rights so far-reaching that the equity of the people in the subject of the permits is forever lost. In other cases the exact nature of the grant is subject for grave dispute between permittees and the Government. The laws should be indubitably certain and just both to the people and to the permittees. It is recommended that all the right-of-way laws be codified and made just, reasonable, and certain. They should give to the permittee security against revocation, except for nonuse or misuse, and a sufficient period of enjoyment. The people, on the other hand, should have, among other reservations to reasonably safeguard their welfare, the certainty that at some reasonable time in the future the subject-matter of the permit will return to their control to be disposed of according to the demands of the public welfare at that time. The right-of-way laws should also provide a definite procedure for the revocation of any right of way because of willful and continued nonuse or misuse of the privilege.

TIMBER UNDER THE CONTROL OF THE UNITED STATES.

Outside of the meager quantities of poor timber remaining upon the unappropriated public domain, the timber still belonging to the United States is 70 per cent in the national forests and 30 per cent in national parks and Indian reservations. Most of the timber in the parks and Indian reservations is not only valuable to the people as a possible future timber supply, but is also of the highest importance, like that upon the national forests, to conserve the run-off of water. Government reserved timber land also conserves natural scenic beauties and wonders, furnishes a health and pleasure resort of value to the people, and stands as a last refuge for the preservation of certain wild animals, birds, and fish, which would otherwise be exterminated. It is recommended that the administration of all the timber lands of the United States be delegated to that governmental agency most fitted to care for it. At the present time the timber of national parks and Indian reservations is suffering badly from lack of broad and scientific management.

CONCLUSIONS CONCERNING THE PUBLIC LANDS.

1. The remaining public lands should be properly classified.
2. Modifications of the public-land laws should protect carefully all rights initiated prior to such changes.
3. The public-land laws should provide for every contingency which might arise in connection with the conservation and administration of the land and other resources belonging to the United States, and should intrust each class of stewardship to that governmental agency best fitted to handle it efficiently.
4. The surface chiefly valuable for agriculture, independent of the disposal of the resources beneath the surface, should be given only to actual homemakers in areas reasonably capable of supporting a family.
5. The surface more valuable for conserving water run-off, unusual natural scenic beauties or wonders, and timber, than for homemaking, should be held by the Government, independent of the disposal of the resources beneath the surface, for the use of all the people, and maintained effectively in a condition to insure its highest efficiency for all time; but such exploitation should not be allowed to impair in any way national parks or national monuments.
6. The right to exploit the mineral resources belonging to the nation and to use a sufficient part of the surface therefor, should be granted to those who actually intend to exploit them, in such limited areas, for such periods, and under such conditions as will, for each class of mineral, bring about seasonable and economical exploitation, but prevent such monopoly as might injure the interests of the people.
7. Rights of way should be allowed for definite and limited periods only, varying for each class of right of way, with reasonable conditions to protect the public interest in the subject-matter and use of the permit and with such certainty to the permittees against revocation during the permit period, for any cause except nonuse or misuse.
8. Pending the disposal of any public land by reservation for public use or by appropriation under the public-land laws, it should be protected by the Government from deterioration and administered so as to serve the best interests of all the people.

So much of the foregoing statement as pertains to the "use and abuse" of our lands was prepared chiefly by Mr. Henry Gannett, of the United States Geological Survey, geographer of the National Conservation Commission.

GEORGE W. WOODRUFF,
Secretary Section of Lands.

MINERAL RESOURCES.

SUMMARY.

The annual products of the mines of the United States now exceed $2,000,000,000 in value. They contribute 65 per cent of the freight traffic of the country. The industry employs over a million men at the mines, and twice that number in handling, transporting, and manufacturing the products.

The waste or losses in the mining, preparation, and use of the mineral products is estimated to exceed $1,500,000 per day.

The available and accessible commercial coal in the United States aggregates approximately 1,400,000,000,000 tons. At the present increasing rate of production this will be depleted and will approach exhaustion before the middle of the next century; and the additional 1,600,000,000,000 tons of inferior coal and lignite not now available economically will approach exhaustion before the end of the next century.

The known supplies of high-grade iron ores in the United States approximate 4,788,150,000 tons, which at the present increasing rate of consumption can not be expected to last beyond the middle of the present century. These are also estimated to be 75,116,070,000 tons of low-grade iron ores which may hereafter be available.

The known supplies of petroleum, natural gas, and high-grade phosphate rock can not be expected to supply the nation's needs through the present century.

The losses from fire in the United States during 1907 were approximately $450,000,000, of which some $400,000,000 was preventable waste.

During 1907 we produced 480,000,000 tons of coal, and the annual production has increased at the average rate of more than 7 per cent. We also produced 52,000,000 tons of iron ore, and the production since 1880 has increased at the average rate of 110 per cent during each of the three decades. In 1907 we produced nearly 870,000,000 pounds of copper; more than 17,000,000 pounds of aluminum; 365,000 tons of lead; 223,000 tons of zinc; 166,000,000 barrels of petroleum; 52,000,000 barrels of cement; 30,000,000 barrels of salt; more than 2,265,000 tons of phosphate rock; and we also extracted clay products to the value of $159,000,000; natural gas, $53,000,000; stone, $71,000,000; gold, $90,400,000; and silver, $37,000,000.

The total value of our metallic products during 1907 was $900,000,000; of mineral fuels, $788,000,000; and of nonmetallic mineral products, other than fuels, more than $378,000,000.

During 1907 our production was 40 per cent of the world's production of coal; 45 per cent of the world's production of iron ore;

22 per cent of its gold; 30 per cent of its silver; 33 per cent of its lead; 27.5 per cent of its zinc; 54.6 per cent of its copper; 52 per cent of its phosphate rock; and 63 per cent of its petroleum.

During the year we imported mineral products to the value of $255,000,000 and exported mineral products to the value of $340,000,000.

BASIS OF ESTIMATES.

Our mineral wealth deserves special consideration and treatment, for the reason that it can not be increased or reproduced. The water for power and other purposes comes and goes continuously up to its limit; the grain crop of one year is succeeded by that of another; within a century one forest may replace another; by still slower process and at great cost the soils which are now being eroded may be replaced from the subsoil or the decay of rocks below; but the deposits of coal which have accumulated during the geologic ages of the past were finished long before man came into existence, and there is but the one supply. As this coal is used it is completely destroyed. No new supply will come when the one now existing is exhausted. The destruction of the metals is slow, but the ore supplies are far more limited than the coal. Of these also there is but one supply; and the metals themselves are slowly but certainly wasted by wear and by various destructive agencies.

The need for an inventory of the mineral resources of the nation grows out of the fact that the production and consumption of these resources are increasing at a rapid rate, and that the mineral supplies for future use are limited.

We should therefore know the quantity of each of these resources available for future use; the increasing rate at which they are being produced or consumed; and the probabilities as to the continuance of this increasing rate. From such data we may form at least an approximate estimate as to the duration of the supplies; and through adequate investigations we may determine the possibilities of increasing the duration of these supplies by developing more efficient methods of production and use.

The incompleteness of the available data renders the making of an inventory of mineral wealth more difficult than that of forests and water resources, and illustrates the need of further investigation. However, the coal fields have been mapped with such accuracy that future discoveries of coal outside of the limits indicated for existing fields are not likely to exceed 1 per cent of the total known supply; and future investigations are likely to diminish rather than increase the estimates of the quantity available within these limits.

Our knowledge of the quantity and distribution of other minerals is less definite, but enough is known to prove that the deposits are limited in extent, and that at the present increasing rates of consumption the supplies of many important minerals will be largely depleted or exhausted before the nation has added another century to its history.

The data for this inventory have been prepared by experts of the United States Geological Survey from records of their investigations and other sources. In the papers by these experts accompanying the commission's report the data are given in detail.

It is not claimed for the statements presented in this inventory of the mineral wealth of the country that the data in all cases are of quantitative exactness or that all the data are of the same degree of accuracy in detail; but all available data have been considered, and only such as are deemed reliable have been used.

Even should future development prove that these estimates are 10 or 20 per cent in error, the need for a wise conservation of resources would stand out none the less prominently and positively. Thus the data for the estimates of coal have been published and distributed among geologists and mining engineers for six months, and the only changes suggested have indicated that the estimates are too high, and that the figures for the duration of the supplies should be reduced rather than increased.

FUEL RESOURCES.

Of all our minerals, the fuels which supply heat, light, and power for domestic and industrial purposes are the most fundamentally essential to the nation. The use of fuels involves their immediate and complete destruction; and increase in the use of other materials also increases the consumption of fuels for both metallurgical and manufacturing purposes, for as the nation has now passed its early development stage, manufacturing, with consequent use of fuels, will increase much more rapidly than will population. A more thorough inventory of the fuels (coal, oil, gas, and peat) is therefore of prime importance.

COAL AND ITS DISTRIBUTION.

The following estimates concerning the original supply, production, and ultimate exhaustion of coal in the United States were prepared by Messrs. M. R. Campbell and E. W. Parker, of the United States Geological Survey, and are based largely on their own investigations, supplemented by data obtained from state geological surveys and private mining companies.

The areas occupied by the anthracite, bituminous, and lignite coal fields aggregate 496,776 square miles, or about 17 per cent of the total area of the country. It is estimated that these coal fields contain a total of 3,000,000,000,000 tons of coal, of which about one-third is regarded as accessible only with difficulty, and not available for mining at the present time. Of the total amount, 1,400,000,000,000 tons of high-grade coal are considered both easily accessible and available for mining under existing conditions.

The geographic distribution of the total coal supply, including that easily accessible and available and 500,000,000,000 tons not now available, is as follows: East of Mississippi River, 800,000,000,000 tons, distributed over an area of 138,022 square miles; west of the Mississippi and east of the hundredth meridian, 160,000,000,000 tons, distributed over an area of 63,044 square miles; in the Rocky Mountain region, including the Great Plains area of Wyoming and the two Dakotas, 930,000,000,000 tons (largely lignites), distributed over an area of 124,700 square miles; and in the Pacific coast States, 10,000,000,000 tons, distributed over an area of 1,830 square miles.

The easily accessible and available anthracite and bituminous coals occupy a total area of 250,531 square miles, and aggregate about 1,160,000,000,000 tons; the lignites, occurring mainly in the Dakotas, Montana, Utah, Colorado, New Mexico, Texas, Louisiana, Mississippi, and Alabama, occupy a total area of 148,609 square miles, and aggregate 385,000,000,000 tons; and the accessible subbituminous coals, ranging in quality between the bituminous and lignite, occupy an area of 97,636 square miles in Montana, Wyoming, and the Rocky Mountain region, and aggregate 355,000,000,000 tons.

The several varieties of bituminous and subbituminous coals and lignites differ to a considerable extent in their composition and heating value, but after giving due consideration both to the quantity and quality of the different coals, it is calculated that the geographical center of coal distribution in the United States is at a point in southeastern Nebraska.

PRODUCTION AND DURATION OF SUPPLY.

From the beginning of coal mining in this country (1814) to the close of 1907 there were mined nearly 7,000,000,000 (6,865,000,000) tons. Adding to this the one-half additional, representing the waste in mining, gives a total of more than 10,000,000,000 tons taken from supplies originally available.

The rate of production has increased rapidly. The average increase from 1846 to the close of 1907 was 7.36 per cent per annum, practically doubling the production every ten years. There has, however, been a decreasing rate of increase in production when considered on a basis of twenty-year averages, and Mr. Henry Gannett, of the United States Geological Survey, on this basis estimates the easily accessible and available coal supplies, aggregating 1,400,000,000,000 tons, would be exhausted by about the year 2027, and that the entire coal supply would be exhausted about the year 2050.

As a practical matter it should be understood that coal production will not increase to a certain point and then cease, but that long before the time of exhaustion of supply has been approached there will come a gradual decline in annual production of coal owing to its increasing scarcity and cost. Already the price of anthracite and some other coals is advancing because of exhaustion of thicker beds and increased cost of working.

The adoption of more efficient methods in connection with the mining and utilization of coal, and the increasing use of water power and other substitutes for fuel in power development will diminish the present increasing rate of consumption, and thereby extend the life of our coal supplies beyond the dates mentioned. On the other hand, it is to be expected that manufacturing will continue to grow more rapidly than population, and this will increase the rate of coal consumption for power purposes even more rapidly than for heating.

The factors in the above estimates are sufficiently reliable to make it clear that without a serious lessening of the present rate of coal consumption, either through more efficient use of this fuel or through the extensive development of substitutes for it, long before the middle of the next century is reached the nation's supplies of available coal will be so largely depleted as to bring serious hardship and a curtailment of industry.

In the earlier days of anthracite coal mining, and in fact until within the last ten years, 40 per cent of the contents of the coal fields was considered a maximum recovery, but conditions have so improved, both in the adoption of better mining methods and in the utilization of what were formerly considered waste sizes, that 60 per cent may now be considered a fair estimate of the coal recovered for commercial use.

It is probable that up to the present time the total loss in the mining and use of bituminous coal has been over 50 per cent of the production. During the last few years, however, the percentage of loss in mining the higher grades of bituminous coal has been largely reduced. This 50 per cent waste includes the coal left in the mine workings for the support of the roof, the coal of lower grades left as unprofitable at current prices, that which is unworkable because of such structural difficulties as faults or dikes and pinchings, and also that rendered unworkable by breaking up due to prior removal of the underlying beds.

The estimated loss in the transportation of anthracite coal is about 2 per cent, and that for bituminous coal is doubtless much larger. On the basis of the 1907 production, this means an annual loss from this source alone of 1,700,000 tons of anthracite coal.

No accurate estimate can be made as to the total unnecessary losses in connection with the use of coal for different purposes, but lines of urgently needed investigation are indicated by the facts that the vast majority of the power plants of the country convert less than 10 per cent of the heat units in the coal into actual work, and that lighting plants convert less than 1 per cent of the heat value of the coal into electric light. The large amounts of gases from blast furnaces are being used to a small but increasing extent in the development of gas-engine power. In the coking industry gases and other by-products to the value of $55,000,000 went to waste in 1907.

EXTENDING THE DURATION OF THE SUPPLY.

The first step in extending our fuel supply should be to lessen the waste in mining, handling, and transportation of coal. There are equally great possible savings in the use of coal, not only in preventing waste now recognized as such, but also in discovering means of avoiding the losses involved in the transformation of heat into mechanical energy, and this into electric energy and light.

Water power will doubtless prove a valuable substitute for coal in the development of power and light in many parts of the country, and the use of the heat of the sun and of alcohol and other organic fuels as substitutes for coal is worthy of serious consideration and investigation.

PEAT.

In European countries where fuel is expensive 10,000,000 tons of peat are used annually for fuel purposes. A preliminary and incomplete examination of the peat beds of the country has developed the fact that they extend over an area of more than 11,000 square miles, the larger part of which is distributed through the New England States, New York, Minnesota, Wisconsin, New Jersey, Virginia, the

Carolinas, and Florida—States which contain little or no coal. Extensive deposits are also found in a few coal-producing States—Iowa, Illinois, Indiana, Ohio, North Dakota, and South Dakota.

This area indicates a possible production of 13,000,000,000 tons of air-dried peat fuel. At $3 per ton in the air-dried form (which would be a reasonable price for fuel in the States having but little coal) this peat would have a fuel value of $39,000,000,000. If all of it were used in by-product gas producers, 640,000,000 tons of ammonium sulphate could be manufactured as a by-product, and at current prices this would have an aggregate value of more than $36,000,000,000.

Recent investigations have shown that much American peat, when dried, will be admirably adapted for use as a source of producer gas for charcoal, for certain grades of coke, for the production of various by-products, for illuminating gas, as a filler for fertilizers, in the manufacture of paper, and for packing material.

PETROLEUM.

The proved oil territory in the United States has fairly exact limitations, but the available information concerning the lateral exhaustion of the pools in this territory and the possible discovery of additional pools is too incomplete to permit of its use as a basis of prediction. Special investigations into the supplies and production of petroleum have been conducted by Dr. David T. Day, of the United States Geological Survey, and these investigations, together with the facts given in the volumes on Mineral Resources of the United States and in the reports of the several state geological surveys, have yielded fairly accurate information concerning the known oil supplies of the country.

The six known petroleum fields aggregate 8,450 square miles, distributed as follows: The Appalachian field, in the States of New York, Pennsylvania, Ohio, West Virginia, Kentucky, and Tennessee; the Lima-Indiana field, in Ohio and Indiana; the Illinois field, in eastern Illinois; the Mid-Continent field, in Kansas and Oklahoma; the Gulf field, in Texas and Louisiana; and the California field. Of these the Illinois, Gulf, and California fields lead in production. The development of these fields has shifted the center of petroleum production rapidly westward to Oklahoma. The yield of oil is from 1,000 to 10,000 barrels per acre, and the total available supply in these fields is estimated at 10,000,000,000 to 24,000,000,000 barrels; perhaps 15,000,000,000 barrels may be taken as a fair average estimate of the available supply. There is, of course, the possibility and even the probability of the discovery of other oil fields as explorations are extended, but these figures must be considered as representing our actual knowledge of the oil resources of the United States.

In 1907 the petroleum production amounted to 166,000,000 barrels. The total amount produced during the last half century is more than 1,800,000,000 barrels. A careful study of the increase in rate of production and consumption during that time indicates that if this increase continues the supply of petroleum will be exhausted before the middle of the present century. However, the present production of petroleum is greater than the legitimate needs of the industry, and should be curtailed. The rapid decline in production of the fields in New York, Pennsylvania, West Virginia, Ohio, Indiana, and Kansas indicates that within a few years the petroleum supply must come in still larger proportion from the more western fields.

One of the essential uses of petroleum is for lubricating purposes. At present fully half a pint of lubricating oil is used for every ton of coal converted into power, and in many branches of industry the proportion of petroleum used is more than twice that amount. Another important use is lighting, and this use also is practically essential, as a greater waste of coal or other fuel is involved in all other forms of lighting.

Such waste as characterizes the natural-gas and coal industries has been remarkably absent in the handling of petroleum in this country. The chief waste which needs mention here is its extensive misuse for purposes that could be easily met through the use of other materials.

During last year 35,000,000 barrels of crude petroleum were burned as fuel in locomotives and steamships and for general power development.

The large exportation of petroleum (30,000,000 barrels in 1907) is still more inimical to the future welfare of the industry. Decidedly beneficial results in extending the life of the supply would come through discontinuance of exportation and decrease of use for fuel.

NATURAL GAS.

Recent investigations of natural gas by the United States Geological Survey, through Dr. David T. Day, show that the known productive territory covers an aggregate area of 10,000 square miles, distributed through 22 States—Alabama, California, Colorado, Illinois, Indiana, Kansas, Kentucky, Louisiana, Michigan, Missouri, Montana, New York, Ohio, Oklahoma, Oregon, Pennsylvania, South Dakota, Texas, Utah, Washington, West Virginia, and Wyoming. Some of the gas fields were at one time abandoned as exhausted, but have subsequently been successfully operated for a time, although under greatly reduced pressures. The life of all the older gas fields, for example, those in portions of Pennsylvania, West Virginia, Ohio, and Indiana, is being exhausted by pumping, and the quantities of gas thus obtained have been unexpectedly large.

Records of the quantity of natural gas have been kept for the last two years only; the value of the annual output is known for the last twenty years or more. The production in 1907 was more than 404,000,000 cubic feet, with a value of more than $52,800,000. The total value recorded by the United States Geological Survey for the twenty years from 1888 to 1907 was $493,649,273.

It is impossible to estimate with even approximate accuracy the total quantity of gas still available for future use in the United States. However, in view of the fact that the known productive areas are limited and the quantity of gas produced in a number of the older fields is diminishing, it is safe to predict that within twenty-five years the known fields will be exhausted.

The waste of natural gas has been one of the chief sins in several States. Drillers for oil have incidentally tapped underground stores of natural gas, and have allowed it to escape until the oil could be produced. Dr. I. C. White, state geologist of West Virginia, estimates that the waste in this manner is now equivalent to a billion cubic feet per day, and has continued for a number of years. In the

Caddo field of Louisiana the daily loss of gas at the present time is estimated as 70,000,000 cubic feet, enough to light ten cities of the size of Washington, and equivalent to a waste of 10,000 barrels of petroleum per day.

This waste indicates most clearly the need of State laws to prohibit the squandering of our natural resources. Such laws applying to natural gas have already been enacted in Indiana, Pennsylvania, and Ohio, and have given gratifying results; and the country will be greatly benefited when other States follow this good example.

The prompt development of new fields of industrial enterprise to utilize the gas or pipe it to existing centers of industry, and penalizing drillers who permit the gas to waste in the air, are urgently required for the conservation of this peculiarly valuable resource.

IRON ORES.

DATA AND CLASSIFICATION.

The iron ores of the United States have been classified by Dr. C. W. Hayes, chief geologist of the United States Geological Survey, with the collaboration of other geologists and mining engineers, on the bases of chemical composition, geologic relations, and geographic distribution. All these classifications have a direct bearing on the commercial value and utilization of the ores. The value of the estimates of tonnage varies widely with different kinds of deposits; about one-eighth of the deposits may be calculated within 10 per cent, nearly three-fourths within 15 to 20 per cent, and the remainder much less closely.

In estimating the tonnage, the ores are divided into (*a*) those available under present conditions and (*b*) those not now available, but which will be used eventually, the division resting on present and prospective costs of delivery to the furnace and of reducing the ore. Among the most important factors of cost are accessibility to transportation, concentration of the deposits permitting large-scale operations, depth below the surface, and composition of the ore, including both the iron content and the character of the impurities. All limy ores carrying over 20 per cent of iron and all siliceous ores carrying over 35 per cent are considered eventually workable, also all material carrying over 4 per cent of wash ore, and all such ores known to occur in the United States are included in the estimates.

The following ore deposits are sufficiently known to indicate the basis and quality of tonnage estimates: (1) Lake Superior ores; (2) Adirondack ores; (3) Clinton ores; (4) Appalachian metamorphic ores; (5) Appalachian brown ores; (6) Appalachian carbonate ores; (7) west Tennessee brown ores; (8) eastern Texas brown ores; (9) Ozark ores; (10) Rocky Mountain metamorphic ores; (11) igneous contact ores.

ESTIMATED SUPPLIES.

The estimates of ore supplies are summarized by districts on purely commercial considerations.

The ores now considered available are estimated to amount to 4,784,930,000 tons, distributed as follows: In the Northeastern States, 298,000,000; in the Southeastern States, 535,220,000; in the Lake

Superior district, 3,510,000,000; in the Mississippi Valley, 315,000,000; in the Rocky Mountain region, 57,760,000; and on the Pacific slope, 68,950,000 tons.

Of low-grade ores not available under existing economic conditions, but which the country may be forced to use in the future, there are estimated to be 74,881,070,000 tons, distributed as follows: In the Northeastern States, 1,095,000,000; in the Southeastern States, 1,041,500,000; in the Lake Superior district, 72,030,000,000; in the Mississippi Valley, 570,000,000; in the Rocky Mountain region, 120,665,000; and on the Pacific slope, 23,905,000 tons.

ORES AVAILABLE FROM OTHER COUNTRIES.

In addition to the ores tabulated, certain foreign deposits which are dependent on the United States market must be taken into account. The most important of these are in Canada and Cuba. Although the amount of iron in these deposits can not be stated with any definiteness, the subjoined table affords some idea of their magnitude. Probably about 5 per cent of the Canadian and from 25 to 40 per cent of the Cuban ores may be available under existing conditions.

Estimated foreign ores tributary to the United States.

	Tons.
Canada and Newfoundland	73,000,000
Cuba	1,505,000,000
Total	1,578,000,000

During the four years 1904 to 1907, inclusive, iron ores were imported into the United States from Cuba, Spain, French Africa, Greece, Newfoundland, Labrador, the United Kingdom, Germany, Holland, Canada, Belgium, France, Norway, British India, and to a less extent from several other countries. The value of the importations steadily increased from $1,101,384 in 1904 to $2,062,161 in 1905, $2,967,434 in 1906, and $3,937,483 in 1907. The tonnage increased from something like 500,000 to about 1,375,000.

PRODUCTION AND DURATION OF SUPPLIES.

Our production of iron ores by decades and the percentage of increase since 1870 (the production of 1908 and 1909 being estimated) were as follows:

Decade.	Production.	Percentage of increase.	Decade.	Production.	Percentage of increase.
1870-1879	49,022,990		1890-1899	183,667,896	80.10
1880-1889	101,969,116	108.00	1900-1909	445,373,480	142.40

The rates of increase are not such as to permit the construction of a curve by which the future production can be predicted. If the average increase of 110 per cent should continue, it would require the production during the next three decades of over 6,000,000,000 (6,329,000,000) tons. The supply of ore now available in the United

States is estimated at 4,784,930,000 tons. It is evident, therefore, that before 1940 either (1) the production will have reached a maximum and begun to decline, or (2) large use must be made of low-grade ores not now classed as available—else the importation of foreign ores must be greatly increased. It should be remembered that in the future use of low-grade ores the conditions will be rendered still further unfavorable through the necessary use of low-grade coals. In view of the many unknown features entering into the problem, the tendency and importance of which are not determinable, any more specific prediction as to the date of the ultimate exhaustion of the iron-ore supplies would be unwarranted.

WASTE AND EXTENSION OF ORE SUPPLIES.

Waste in the handling of iron ores in the Lake Superior district is being reduced to a small amount. The mining companies are displaying a commendable spirit not only in preventing waste of the high-grade ores, but in storing for future use the low-grade ores which it may be necessary to bring to the surface in mining operations, although not suitable for use under existing economic conditions. In other districts, especially those containing the Clinton ores, a considerable quantity of good material is at present left in the mines for the support of the roof. The waste in manufacturing is also guarded against with considerable care.

The principal factors in extending the duration of the supplies of high-grade ore will come through the utilization of the low-grade ore and through the lessening of the demand for iron and steel by developing substitutes for those materials in construction and other work.

GOLD, SILVER, COPPER, LEAD, AND ZINC.

Data concerning the ore supplies of these major metals have been prepared by Mr. Waldemar Lindgren, of the United States Geological Survey, whose report, largely based on the investigations of the Survey geologists, is appended.

THE ORE SUPPLIES.

The data are entirely inadequate for estimating the existing supplies of these metals, for the reason that they, or the ores from which they are produced, as a rule occupy comparatively small spaces, irregular and uncertain in occurrence, which can not be mapped and described with accuracy in advance of mining operations.

The areas in which these metals are known to occur, or where they may be reasonably expected to be found, are widely separated, and comprise in the aggregate less than one-third of the total area of the United States; and from this third may be excluded large areas in which the discovery of deposits is extremely unlikely.

The more important known available gold supplies are in Alaska, California, Colorado, and Nevada, all the other States contributing about one-fifth of the present total annual output. Silver is known to be mainly in Colorado, Montana, Utah, Nevada, and Idaho; lead in Missouri, Idaho, Utah, and Colorado; zinc in Missouri, New Jersey, Colorado, Wisconsin, and Kansas; and copper in Arizona, Montana, Michigan, Utah, Nevada, California, and Tennessee.

As compared to the certain future needs of the nation, the proved supplies of these metals are not great, but the discovery of large additional workable deposits is probable as the prospecting of the country is extended. Large deposits of low-grade ores are known to exist, which, although not now available for treatment, will become available as prices advance or as new processes permit handling and treatment at less cost.

PRODUCTION AND DURATION OF SUPPLIES.

A gold production of $60,000,000 was recorded in 1852 and 1854. From that time it decreased gradually to $30,000,000 in 1883, then rose to $33,000,000 in 1892. Since that time the increase has been rapid, and record figures of over $94,000,000 were reached in 1906. In 1907 the production fell to $90,400,000.

Important production of silver began about 1860 and rapidly increased, amounting to 63,500,000 ounces in 1892. Since then the output has remained practically constant, averaging about 55,000,000 ounces yearly.

Copper production has grown at a very rapid and almost constant rate, reaching its maximum in 1906, when the output was almost 918,000,000 pounds. In 1907 it declined to very nearly 869,000,000 pounds.

From 1885 to 1895 the lead production grew at a moderate rate from 129,000 to 170,000 tons. Since 1895 the increase has been much more rapid, and in 1907 the production was 365,166 tons.

Zinc production, which was of little importance in 1880, began to increase decidedly in 1896. In that year the spelter output was 81,000 tons, and in 1907 it increased to 223,745 tons. Including that manufactured into paint, the total production in 1907 was 280,676 tons.

As to the duration of the supplies, data are not available for specific estimates. With a continuation of the present increasing rate of production, the known ores workable under present conditions will be exhausted before the middle of the present century; yet no such prediction can be made without qualification. Full knowledge of our metal resources can be gained only by exploration, and exploration does not materially anticipate unusual demand. Ten years ago a review of our metal supplies would have revealed a greater shortage than now exists, and it is quite possible that in the case of some metals our visible stock may be greater some ten years hence than at present.

Improvements in processes are steadily reducing the cost of reduction, and this will bring many ore bodies of lower grades now considered unprofitable into the list of available supplies.

PHOSPHATE ROCK.

Mr. F. B. Van Horn, of the United States Geological Survey, has brought together all available information concerning the supplies of phosphate rock in the United States. These are distributed along the western coast of Florida, along the coast of South Carolina, in central Tennessee, and in an area recently discovered in southeastern Idaho, northwestern Wyoming, and northeastern Utah. The data are not sufficiently complete to make a trustworthy estimate of the total existing supply.

The best estimate of high-grade phosphate rock that can be made at the present time is as follows:

	Tons.
South Carolina	3,000,000
Florida	15,000,000
Tennessee	103,500,000
Western States (Idaho, Wyoming, and Utah)	100,000,000
Total	221,500,000

In addition there are large supplies of low-grade phosphate rock, carrying from 25 to 50 per cent of calcium phosphate, for which there is now no demand, but which may find a market after the high-grade rock, containing from 60 to 80 per cent of calcium phosphate, has been consumed. Doubtless the advance in price which will precede exhaustion will hasten the development of methods rendering the use of the low-grade rock possible. No quantitative estimate of low-grade phosphate rock can be made at present.

During 1907 the production of phosphate rock was 2,265,343 tons. The total amount mined from the beginning, in 1867, to the end of 1907 was about 29,200,000 tons. The rate of increase in production in the last twenty years has averaged 117 per cent for each decade. Should this rate of increase continue the available supply of high-grade rock will be exhausted in twenty-five years.

Increase in population and the development of intensive farming will eventually extend the demand for phosphates and other fertilizing materials already existing in the Southern States. A partial contribution toward meeting this future demand will come from a more complete and efficient use on the farm of animal excrement, including that which may be procured from sewage and other sources; but to meet any large demand for phosphate materials, recourse must be had to the mineral supplies.

It is probable that additional deposits of high-grade phosphate rock may be discovered, and the duration of the known phosphate product may be extended by more efficient methods of mining and treatment. In the phosphate industry the plan now in practice to some extent in iron mining, of laying aside for the future all material too low in grade for economical use at present, should be adopted.

Another means of extending the supply lies in discontinuing exports of this material. During 1907 the United States exported 1,018,212 tons of high-grade rock, or about 45 per cent of the entire output. The total amount of high-grade material exported during the last nine years was 7,504,519 tons.

MISCELLANEOUS MINERAL RESOURCES.

Many branches of our mineral industry are based on additional mineral substances, which occur in greater or less abundance. Of these the supplies of abrasive materials, as quartz, feldspar, garnet, grindstone, infusorial earth, millstone, oilstone, and such other minerals as mineral waters, mineral paints, low-grade graphite, talc, gypsum, and salt, appear to be sufficient to meet the needs of the nation's future as well as the present demands.

The supplies of sulphur, asphalt, magnesite, borax, asbestos, and fibrous talc, like those of coal and iron ores, are clearly soon exhaustible, though if wisely used they may be reasonably expected to extend beyond the limits of the present century. Our supplies of manganese ores, bauxite, quicksilver, antimony, high-grade graphite, corundum, and mica, like those of petroleum, natural gas, copper, gold, silver, lead, zinc, and phosphate rock, will be largely depleted or exhausted well within the present century unless known deposits are largely augmented by new discoveries. To this list may be added certain minerals of which only small quantities have yet been found in this country, such as nickel, cobalt, chromium, tin, platinum, antimony, bismuth, cadmium, tungsten, uranium, vanadium, molybdenum, and tantalum.

STRUCTURAL MATERIALS.

Data concerning the supplies and uses of structural materials and their waste through fire losses have been collected and prepared for the commission by Mr. H. M. Wilson, of the United States Geological Survey.

SUPPLIES AND USE.

The supplies of many of the materials used in building and engineering construction, such as stone, sand, gravel, clays, cement, lime, and salts, are practically inexhaustible, and for that reason need not be extensively discussed.

The use of these materials has been restricted heretofore by the wide difference in price between forest products and mineral products; but owing to improved methods the cost of the latter has been diminished, while that of wood products has advanced. Within the last decade the value of cement manufactures increased from $9,900,000 to $55,900,000, or nearly sixfold; and the value of clay products from $74,500,000 to $159,000,000, or more than double. In the same period the value of building stone increased from $28,600,000 to $71,100,000, or nearly threefold. A still larger relative increase in the use of these more durable building materials may be looked for, since the Government is determining the strength, durability, and fire-resistant properties of these materials, and is disseminating information as to the comparative cheapness of the more permanent work.

Through lack of exact knowledge as to the strength of these materials, present systems of building construction are expensive. Engineers and architects adopt working stresses for concrete and for metal construction ranging from one-fourth to as high as one-eighth the supposed working strength of the material, and this means that from three to six times the necessary amount of material is used.

WASTE OF MATERIAL.

The waste of minerals used in building and engineering construction comprises (1) that due to improper and wasteful methods of mining and preparing for market; (2) that due to the use of excessive quantities of material because of ignorance concerning strength and durability; and (3) that due to destruction by fire.

In addition to the waste of raw mineral products due to improper methods of mining and shipping, there is a large waste of material due to careless and inefficient methods of manufacture. Not until better knowledge is gained as to the appropriate structural material for each particular use—steel, iron, cement, or clay products—will it be possible to materially lessen this waste.

FIRE LOSSES.

The greatest source of waste of structural materials and of money values is fire. It is one which, from the example set in European countries, can be most rapidly reduced by the substitution of fire-resisting materials for the inflammable construction now prevalent.

The cost to the country of fire, including only property destroyed, was $217,500,000 in 1907. The cost of preventive measures, maintenance of fire departments, protective agencies, and additional cost of water supplies raised the total to over $450,000,000.

A notable fact in the analysis of fire losses is that 27 per cent were due to exposure—that is, the fire extending beyond the building in which it originated. The extension of fires results from the use of inflammable material in construction. It is even more notable that only $68,000,000 of the loss was on brick, concrete, stone, and other slow-burning construction, while over double that amount, or about $148,000,000, was on frame buildings. In the last thirty-three years the total fire waste amounted in value of property destroyed to over $4,500,000,000.

It is a reasonable estimate that one-fifth of the city water supply and distribution charges, three-fourths of the fire department charges, and over four-fifths of the fire losses, or a total of nearly $400,000,000 per year, may be considered a preventable tax on the nation.

CONSUMPTION AND WASTE.

The recent rapid increase in the production and consumption of mineral materials forms one of the important and striking general facts brought out in the work of the commission, and this fact is of vital importance in any consideration of the duration of these resources.

This consumption of mineral products has increased more rapidly than population. Thus, in 1880 we used 1.5 tons of coal per capita; in 1890, 2.5 tons; in 1900, 3.5 tons; and in 1907, 5.6 tons. Of pig iron we used in 1880, 200 pounds per capita; in 1890, 320 pounds; in 1900, 391 pounds; and in 1907, 686 pounds. Of copper we used in 1890, 3 pounds per capita; in 1900, 4.6 pounds; and in 1907, 6.4 pounds. Of cement we used in 1890, 70 pounds per capita; in 1900, 92 pounds; and in 1907, 228 pounds.

The striking features in the economic history of the nation during the past century were the development of agricultural and mining industries and the beginning of manufacturing and transportation. The striking feature in the economic development of the nation during the present century will be the rapid extension of manufacturing and transportation industries. This will both require and explain the continuance of a rapid increase in the rate of mineral production and consumption. Nothing can check this development save the premature depletion of the resources which are essential to its progress. The prevention of such depletion is worthy of the best effort of the nation itself.

While the data are not available for an accurate quantitative estimate of the losses connected with the mining, treatment, and use of our mineral resources, the facts in hand indicate that they exceed one-fourth of the total value of our present mineral production, or $500,000,000 yearly.

LOSS OF LIFE IN MINING INDUSTRIES.

Even more serious than the question of waste of materials is the excessive loss of life in our mining and metallurgical operations. During the past year in our coal mines nearly 3,000 men were killed and more than 7,000 were injured. During the past ten years nearly 20,000 men have been killed and probably 50,000 injured.

The number killed and injured in connection with metal mining and quarrying and in the metallurgical industries during the past year is not known, but the number will doubtless add materially to the sad record in the coal mines. The seriousness of this record is increased by the fact that the number of killed and injured for each thousand men employed in the coal mines was greater in 1900 than in 1895, greater in 1905 than in 1900, and greater in 1907 than during any earlier year of our history. This is the natural outcome of the deepening of mines and the employment of an increased percentage of untrained foreigners, rendered necessary in our mining operations by existing economic conditions. It is to be hoped that the record of 1907 represents the end of the increasing progression of killed and injured, and that henceforth loss of life will steadily and rapidly diminish through the cooperation of miners, operators, state and federal governments, and the general public.

A RATIONAL BASIS FOR THE CONSERVATION OF MINERAL RESOURCES.

In considering the conservation of resources it should be held in mind that:

(1) The present generation has the power and the right to use efficiently so much of these resources as it needs.

(2) The nation's needs will not be curtailed; these needs will increase with the extent and diversity of its industries, and more rapidly than its population.

(3) The men of this generation will not mine, extract, or use these resources in such manner as to entail continuous financial loss to themselves in order that something be left for the future. There will be no mineral industry without profits.

One of the essential steps is to adopt fundamental principles which give conservation as applied to mineral resources a rational basis. Some of the more important of these principles are as follows:

(1) The resources which have required ages for their accumulation, to the intrinsic value or quantity of which human agency has not contributed, which when once exhausted are not reproduced, and for which there are no known substitutes, must serve as a basis for the future no less than for the present welfare of the nation. In the highest sense, therefore, they should be regarded as property held in trust for the use of the race rather than for a single generation, and for the use of the nation rather than for the benefit of the few individuals who may hold them by right of discovery or by purchase.

(2) Measured in terms of the needs of a great and rapidly growing country, the mineral resources are limited in quantity.

(3) Measured in terms of the life of the nation, at the present increasing rate of consumption and waste we will, while the country is yet in its infancy, exhaust the resources necessary as the essential basis for the welfare of all succeeding generations. To shirk this responsibility on the claim that succeeding generations will probably discover other now unknown resources for their use is unjust and irrational.

(4) The right of the present generation to use efficiently of these resources what it actually needs carries with it a sacred obligation not to waste this precious heritage.

(5) The right to profit in the mining and utilization of our mineral resources does not carry with it the right to destroy the birthright of generations yet unborn, in order that we of to-day may obtain more easily and more cheaply the products we need for present use.

(6) It is therefore reasonable to expect that the users of mineral products will pay for them such higher prices as will make profitable their mining and preparation without serious waste.

(7) It is also reasonable to expect that the resulting increase in the first cost of the crude material will insure their more efficient use, and that this in turn will both help to keep down the ultimate cost of finished products and to conserve the resources.

(8) The very abundance and cheapness of our resources have developed an American habit of waste which is the greatest menace to our future welfare. This waste of the past and present entails on us a still greater obligation to strive for the highest possible efficiency in the future mining and use of these resources.

HOW THE DURATION OF THE SUPPLY MAY BE EXTENDED.

The extension of the supply of our more important mineral resources is absolutely essential to the future welfare of the nation. How to accomplish this is a problem demanding the consideration of the best science and statesmanship the country affords.

First of all is the prevention of unnecessary waste; and for this the individual and the State and Federal governments must cooperate.

All unscientific or inefficient use of resources is waste; and the most important element in conservation is the fact that the necessary waste of to-day may, through inquiry or research or through economic conditions, become the avoidable waste of to-morrow.

The waste of these essential resources being a matter of serious national concern, it is a proper function of the Federal Government to conduct such investigations as may be necessary to determine the nature and extent of the losses of life and resources and to indicate how they may be prevented.

The Federal Government has inaugurated and has well under way investigations into the nature and causes of coal-mine explosions, with a view to their prevention; into the character and value of our coals, and into the nature and extent of the waste in coal mining; concerning the fundamental problems of combustion, with a view to preventing waste in the use of fuels; and into the nature and extent of materials of construction, with a view to their more efficient use by the Government and the people, and to the prevention of disastrous fires. To these might be added similar investigations looking to the prevention of waste in the mining, treatment, and use of other mineral substances.

Such investigations being of service to all the people and to all the States, and being national in their purpose, may be conducted more efficiently by the General Government, as duplication in labor and cost are avoided where it would exist if the work were undertaken by the States or by individuals.

The cooperation of the States in this movement is essential as covering investigations of local problems and the enforcement of such legislation as might prove necessary in securing the fullest cooperation of the individual, who is naturally apt to consider first of all the question of immediate financial return on his investments. But the cooperation of the individual in the movement for the conservation of resources is needed, and may be counted on to the fullest extent that economic conditions will permit.

The duration of our mineral resources may be still further extended through investigations looking toward the substitution of common mineral substances for those which more rapidly approach exhaustion because of their rarity or greater importance, as, for example, the substitution of concrete for structural steel; of low-grade coals or lignite for those of higher grade; and of water power for steam.

Furthermore, in the case of certain supplies which are now being largely exported, or in the use of which waste is excessive, the duration may be extended for domestic use through such ownership or control as will prevent both sending out of the country and unnecessary waste.

Again, the prevention of waste, and hence the extension of the life of supplies, may be secured through such increase in the price of materials as will render practicable their more complete extraction and efficient use.

The miners and operators in our coal mines are both anxious to inaugurate reforms looking to greater safety and efficiency in mine operation, but the price of coal in the United States is too low to render possible many of the reforms which in other countries are successfully based on a price at the mine twice that in this country. It is believed, however, that when this situation is fully understood the American people will be ready and willing to pay whatever increase in the cost of fuel may be found necessary in order to guarantee the safety of the miner and to prevent the waste of resources, the preservation of which is no less essential to the nation's future than to its present welfare. The American consumer can regain the additional cost of the coal by handling and using it with correspondingly greater care and efficiency.

J. A. Holmes,
Secretary, Section of Minerals.

ORGANIZATION AND PROCEEDINGS OF THE NATIONAL CONSERVATION COMMISSION.

ORGANIZATION AND PROCEEDINGS OF THE NATIONAL CONSERVATION COMMISSION.

On June 8, 1908, the National Conservation Commission was created by the President. The President's letter to those designated to serve on the commission is as follows:

THE WHITE HOUSE,
Washington, June 8, 1908.

The recent conference of governors in the White House confirmed and strengthened in the minds of our people the conviction that our natural resources are being consumed, wasted, and destroyed at a rate which threatens them with exhaustion. It was demonstrated that the inevitable result of our present course toward these resources, if we should persist in following it, would ultimately be the impoverishment of our people. The governors present adopted unanimously a declaration reciting the necessity for a more careful conservation of the foundations of our national prosperity, and recommending a more effective cooperation to this end among the States and between the States and the nation. A copy of this declaration is inclosed.

One of the most useful among the many useful recommendations in the admirable declaration of the governors relates to the creation of state commissions on the conservation of resources, to cooperate with a federal commission. This action of the governors can not be disregarded. It is obviously the duty of the Federal Government to accept this invitation to cooperate with the States in order to conserve the natural resources of our whole country. It is no less clearly the duty of the President to lay before the Federal Congress information as to the state of the Union in relation to the natural resources, and to recommend to their consideration such measures as he shall judge necessary and expedient. In order to make such recommendations the President must procure the necessary information. Accordingly, I have decided to appoint a commission to inquire into and advise me as to the condition of our natural resources, and to cooperate with other bodies created for a similar purpose by the States.

The Inland Waterways Commission, appointed March 14, 1907, which suggested the conference of governors, was asked to consider the other natural resources related to our inland waterways, and it has done so. But the two subjects together have grown too large to be dealt with by the original body. The creation of a commission on the conservation of natural resources will thus promote the special work for which the Inland Waterways Commission was created, and for which it has just been continued and enlarged, by enabling it to concentrate on its principal task.

The Commission on the Conservation of Natural Resources will be organized in four sections to consider the four great classes of water resources, forest resources, resources of the land, and mineral resources. I am asking the members of the Inland Waterways Commission to form the section of waters of the National Conservation Commission. In view of the lateness of the season and the difficulty of assembling the members of the sections at this time, a chairman and a secretary for each section have been designated, and the chairmen and secretaries of the sections will act as the executive committee with a chairman who will also be chairman of the entire commission. I earnestly hope that you will consent to act as a member of the commission.

One of the principal objects of the federal Commission on the Conservation of Natural Resources will be to cooperate with corresponding commissions or other agencies appointed on behalf of the States, and it is hoped that the governors and their appointees will join with the federal commission in working out and developing a plan whereby the needs of the nation as a whole and of each State and Territory may be equitably met.

The work of the commission should be conditioned upon keeping ever in mind the great fact that the life of the nation depends absolutely on the material resources which have already made the nation great. Our object is to conserve the foundations of our prosperity. We intend to use these resources; but to so use them as to conserve them. No effort should be made to limit the wise and proper development and application of these resources; every effort should be made to prevent destruction, to reduce waste, and to distribute the enjoyment of our natural wealth in such a way as to promote the greatest good of the greatest number for the longest time.

The commission must keep in mind the further fact that all the natural resources are so related that their use may be, and should be, coordinated. Thus the development of water transportation, which requires less iron and less coal than rail transportation, will reduce the draft on mineral resources; the judicious development of forests will not only supply fuel and structural material but increase the navigability of streams, and so promote water transportation; and the control of streams will reduce soil erosion and permit American farms to increase in fertility and productiveness, and so continue to feed the country and maintain a healthy and beneficial foreign commerce. The proper coordination of the use of our resources is a prime requisite for continued national prosperity.

The recent conference of the governors, of the men who are the direct sponsors for the well-being of the States, was notable in many respects; in none more than in this, that the dignity, the autonomy, and yet the interdependence and mutual dependence of the several States were all emphasized and brought into clear relief, as rarely before in our history. There is no break between the interests of state and national; these interests are essentially one. Hearty cooperation between the state and the national agencies is essential to the permanent welfare of the people. You, on behalf of the Federal Government, will do your part to bring about this cooperation.

In order to make available to the National Conservation Commission all the information and assistance which it may desire from the federal departments, I shall issue an executive order directing them to give such help as the commission may need.

The next session of Congress will end on March 4, 1909. Accordingly, I should be glad to have at least a preliminary report from the commission not later than January 1 of next year.

Sincerely, yours,

THEODORE ROOSEVELT.

Personnel of the National Conservation Commission.

WATERS.

Theodore E. Burton, Ohio, chairman.
Francis G. Newlands, Nevada.
Jonathan P. Dolliver, Iowa.
William Warner, Missouri.
John H. Bankhead, Alabama.
W J McGee, Bureau of Soils, secretary.
F. H. Newell, Reclamation Service.
Gifford Pinchot, Forest Service.
Herbert Knox Smith, Bureau of Corporations.
Joseph E. Ransdell, Louisiana.
G. F. Swain, Massachusetts Institute of Technology.
W. L. Marshall, Brigadier General, U. S. Army, Chief of Engineers.

FORESTS.

Reed Smoot, Utah, chairman.
Albert J. Beveridge, Indiana.
Charles F. Scott, Kansas.
Champ Clark, Missouri.
J. B. White, Missouri.
Henry S. Graves, Yale Forest School.

Wm. Irvine, Wisconsin.
Newton C. Blanchard, Louisiana.
Charles L. Pack, New Jersey.
Irving Fisher, Connecticut.
Gustav H. Schwab, New York.
Overton W. Price, Forest Service, secretary.

LANDS.

Knute Nelson, Minnesota, chairman.
Francis E. Warren, Wyoming.
Swagar Sherley, Kentucky.
Herbert Parsons, New York.
N. D. Broward, Florida.
James J. Hill, Minnesota.
Geo. C. Pardee, California.
Charles Macdonald, New York.
Murdo Mackenzie, Colorado.
T. C. Chamberlin, University of Chicago.
Frank C. Goudy, Colorado.
Geo. W. Woodruff, Interior Department, secretary.

MINERALS.

John Dalzell, Pennsylvania, chairman.
Joseph M. Dixon, Montana.
Frank P. Flint, California.
Lee S. Overman, North Carolina.
Philo Hall, South Dakota.
James L. Slayden, Texas.
Andrew Carnegie, New York.
Charles R. Van Hise, Wisconsin.
John Mitchell, Illinois.
John Hayes Hammond, Massachusetts.
I. C. White, West Virginia.
J. A. Holmes, Geological Survey, secretary.

EXECUTIVE COMMITTEE.

Gifford Pinchot, chairman.
Theodore E. Burton.
Reed Smoot.
Knute Nelson.
John Dalzell.
W J McGee.
Overton W. Price.
G. W. Woodruff.
Joseph A. Holmes.

Secretary of the Commission, Thomas R. Shipp (elected by the executive committee).

At the time the National Conservation Commission was created, the Inland Waterways Commission, appointed on March 14, 1907, was reappointed. Three members were added and the commission was made the section of waters of the National Conservation Commission. The President's letter reappointing the Inland Waterways Commission is as follows:

THE WHITE HOUSE,
Washington, June 5, 1908.

The Inland Waterways Commission was appointed on March 14, 1907. It was appointed to meet the strongly expressed and reasonable demands of the people. Commercial organizations throughout the Mississippi Valley and elsewhere demanded then and still demand such improvement of waterways and development of navigation as will prevent traffic congestion and develop commerce. It is an unpleasant fact that, although the Federal Government has in the last half century spent more than a third of a billion dollars in waterway improvement, and although the demand for transportation has steadily increased, navigation on our rivers has not only not increased, but has actually greatly diminished. The method hitherto pursued has been thoroughly ineffective; money has been spent freely for improving navigation, but river navigation at least has not been improved, and there is a just and reasonable demand on the part of the people for the improvement of navigation in our rivers in some way which will yield practical results. It was for such reasons as these that the commission of which you are chairman was requested to consider and recommend a general plan of waterway improvement giving reasonable promise of effectiveness.

The preliminary report of the Inland Waterways Commission was excellent in every way. It outlines a general plan of waterway improvement which when adopted will give assurance that the improvements will yield practical results in the way of increased navigation and water transportation. In every essential feature the plan recommended by the commission is new. In the principle of coordinating all uses of the waters and treating each waterway system as a unit; in the principle of correlating water traffic with rail and other land traffic; in the principle of expert initiation of projects in accordance with commercial foresight and the needs of a growing country; and in the principle of cooperation between the States and the Federal Government in the administration and use of waterways, etc., the general plan proposed by the commission is new and at the same time sane and simple. The plan deserves unqualified support. I regret that it has not yet been adopted by Congress, but I am confident that ultimately it will be adopted.

Pending further opportunity for action by Congress the work of the commission should be continued, with the view of still further perfecting the general plan by additional investigations and by ascertaining definitely and specifically why the methods hitherto pursued have failed. To this end I ask that the present members of the Waterways Commission continue their most commendable public service. I am asking three others to join them, namely: Senator William B. Allison, of Iowa; Hon. Joseph E. Ransdell, of Louisiana, a member of the Rivers and Harbors Committee of the House of Representatives and president of the National Rivers and Harbors Congress; and Prof. George F. Swain, of the Massachusetts Institute of Technology, a recognized authority on water power. When a Chief of Engineers is appointed to succeed General Alexander Mackenzie, retired, I shall also designate him a member, in lieu of General Mackenzie, whose retirement relieves him of further duty on the commission. The commission will thus be increased from 9 members to 12.

In order to facilitate the work of the commission I shall shortly issue an executive order along the lines suggested by your findings and recommendations, directing the executive departments to give the commission access to their records and all necessary and practicable assistance in securing information for submission to the President and to Congress.

An indirect but useful result of the work of the commission was the recent conference of governors on the conservation of our natural resources, held in the White House May 13–15. I take great pleasure in repeating my public expression of indebtedness and my congratulations to the commission for their signal public service in connection with this great conference; it was an event which is likely to exert a profound and lasting influence on the development and history of our country.

Copies of this letter are being sent to each of the twelve members of the Inland Waterways Commission.

Sincerely, yours,

THEODORE ROOSEVELT.

The executive committee of the National Conservation Commission, which was also designated by the President, met in Chicago on June 19, 1908. and elected Thomas R. Shipp secretary of the commission.

The committee authorized the chairman and secretary of the commission to correspond with governors and other state officials and with national organizations concerned with natural resources. It agreed to write the governors, or representatives to be appointed by them, to participate in a meeting with the National Conservation

Commission on December 8, 1908. The date for the first general meeting of the commission was fixed for December 1, 1908. It was agreed that the executive committee should issue bulletins of progress from time to time, announcing places and dates of meetings and conveying other information of service to the commission. It was decided that in the collection of information the chairman and secretary of each section should act in behalf of the section and that the data collected should be coordinated by the chairman of the commission. By general agreement, the chairman was instructed to invite all necessary expert assistance in the preparation of special statements and reports.

The compilation of data planned by the executive committee was authorized by the following executive order of the President:

EXECUTIVE ORDER.

A national conservation commission to consider and advise the President upon the condition and needs of the natural resources of the country has been appointed by the President. The heads of the executive departments, bureaus, and other government establishments are hereby instructed to secure, compile, and furnish to the said commission all such information and data relevant to its work as the commission may from time to time request, and as may be respectively within the lawful powers of such departments, bureaus, and government establishments to secure, compile, or furnish, and not inconsistent with express provisions of law.

THEODORE ROOSEVELT.

THE WHITE HOUSE, *June 8, 1908.*
(No. 809.)

Under authority of this executive order, the conservation commission undertook the making of an inventory of the natural resources of the United States, in cooperation with the executive departments of the Government, state officers, and with national organizations. General supervision of the compilation of material was placed in the hands of Mr. Henry Gannett, whom the President assigned to assist the commission in its work.

The work of the commission was greatly aided by the rapid appointment of state conservation commissions, which now number thirty-five.

In addition to the cooperation of state and federal agencies, the national organizations rendered valuable assistance. These organizations named conservation committees to act in cooperation with the national commission, which now reach a total of forty-one.

The first meeting of the National Conservation Commission was held in the Library of Congress, Washington, beginning December 1 and ending December 7.

Its sessions were devoted to the discussion of the inventory of natural resources, presented by the chairman and secretaries of sections, and to the preparation of the report of the National Conservation Commission to the President, which was unanimously adopted.

The report of the commission was presented to the joint conservation conference, which met in Washington December 8–10, at which, conferring with the National Conservation Commission, were 20 governors of States and Territories, personal representatives of 11 governors and governors-elect, members of 26 state conservation commissions, and presidents and representatives of 60 national organizations.

Supplementing the report, the summaries of the four sections of the commission were presented and thoroughly discussed by the governors and the conferees, after which the committee on resolutions, consisting of the governors, ex-governors, and governors-elect who were present, united in resolutions, which were unanimously adopted and which are submitted with the report of the commission. The verbatim proceedings of the joint conservation conference are also submitted with this report.

THOMAS R. SHIPP,
Secretary to the Commission.

PROCEEDINGS OF THE
JOINT CONSERVATION CONFERENCE.

PROCEEDINGS OF THE JOINT CONSERVATION CONFERENCE.

WASHINGTON, D. C., *December, 8, 9, 10, 1908.*

GENERAL MEETING.

TUESDAY AFTERNOON, DECEMBER 8.

The Joint Conservation Conference was called to order in the Belasco Theater at 4.15 o'clock p. m., December 8, by Gifford Pinchot, chairman of the National Conservation Commission. Dr. Edward Everett Hale, chaplain of the United States Senate, pronounced the invocation, the audience joining with him in repeating the Lord's Prayer after he had read the following:

INVOCATION—DR. EDWARD EVERETT HALE.

Bless the Lord, O my soul. O Lord, my God, Thou art very great. Thou art clothed with honor and majesty. He maketh the winds His angels. He laid the foundations of the earth, that it should not be removed forever.

Thou sendest the springs into the valleys: Thou waterest the hills from Thy chambers. The earth is satisfied with the fruit of Thy works.

Thou causeth the grass to grow for the cattle and herbs for the service of man. Thou renewest the face of the earth. Thou givest their meat in due season. Thou openest Thine hand. They are filled with good.

The glory of the Lord shall endure forever. The Lord shall rejoice in His works.

Mr. PINCHOT. Mr. President, ladies and gentlemen, the meeting of governors at the White House last May, out of which this joint conference sprang, considered the natural resources of our country as the foundations of our prosperity. The conservation of these resources is clearly necessary for our welfare as a nation, now and hereafter.

Conservation implies both the development and the protection of resources, the one as much as the other. The idea which underlies it is in harmony with the true spirit of this nation. It expresses a deep-seated national conviction, latent until it came, that we have inherited from our forefathers both an opportunity for ourselves and a duty to those who come after us. Conservation demands the use of common prudence and common foresight in dealing with the great material resources upon which our present and future welfare depends.

The essence of conservation is the application of common sense to the common problems for the common good.

Conservation is simple, obvious, and right. Therefore, of all the great movements of our recent history not one has gained so fast in public appreciation and support and not one promises such results in assuring the greatest good to the greatest number for the longest time.

This nation has 3,000,000 square miles of the richest, the most varied, and the pleasantest of the continents. That land belongs to us now, just as it has belonged to our forefathers, and as it will belong to our descendants. We have the right to use it, and we have the power to impair it. The choice is ours. We can not avoid it, and we can not delay it. That we shall choose well, this meeting is the best earnest and guarantee.

The history of a nation is written best of all in the progress and happiness of its people. But it is written also in great movements, great occasions, and great men. We are gathered here to-day in the furtherance of a great movement, on a great occasion, and in the presence of great men.

I have the honor to present to you your chairman, the President-elect.

Mr. Taft. Mr. President, ladies and gentlemen, there is one difficulty about the conservation of natural resources. It is that the imagination of those who are pressing it may outrun the practical facts.

I have been introduced as the President-elect. I am not the President-elect, except in the imagination of Mr. Pinchot.

But it gives me great pleasure, as an unofficial person, to present the President of the United States.

ADDRESS OF PRESIDENT ROOSEVELT.

The President. This audience is very kind to the setting sun, and without being the seventh son of the seventh son, I can prophesy who will be the President-elect.

But, first of all, speaking to you as a private person, Judge Taft, governors, Representatives of the States, and of the great national organizations, members of the National Conservation Commission, and you men and women, my fellow-citizens, I welcome you here, our guests, to Washington and to the work you have gathered to do. No service to the nation in time of peace could be of greater worth than the work which has brought you together.

In its essence your task is to make the nation's future as great as its present. That is what the conservation of our resources means. This movement means that we shall not become great in the present at the expense of the future, but that we shall show ourselves truly great in the present by providing for the greatness of our children's children who are to inherit the land after us. It is the largest national task of to-day, and I thank you for making ready to undertake it. If you do no more than fix the national attention upon the problem, you will yet have done well. It augurs well for our future that you are here; and it is to the credit of our country that in this matter it should take the lead among the nations of the world.

All that we are asking, gentlemen, is that the National Government shall proceed as a private business man would as a matter of course proceed. He would regularly take account of stock so that he may know just where he stands; if you find that he does not know how his outgo corresponds with his income, you will not trade with him; you would be afraid to. The same measure of prudence demanded from him as an individual, the same measure of foresight, is demanded of us as a nation. Unfortunately nations have been slow to profit by the example of every individual among them who makes a success of his business. The United States is substantially the first nation to take an inventory of its stock on hand, and it has only begun to do so in any definite way within the last few months.

Last May the governors of the States and Territories met in the White House to confer with each other and with the President upon the material basis of our national welfare. They united in a memorable declaration which should hang on the wall in every school, for every citizen who is to be a voter in the next generation should grow up accepting as axiomatic the declaration of principles promulgated by your body last spring. One outcome of the conference at which the declaration was adopted was the appointment of a National Conservation Commission, whose chief duty was to prepare an inventory of the natural resources of our country—those resources which are, in the language of the governors, the foundations of our prosperity. This report is to be used by the President in transmitting to Congress information as to the state of the Union so far as the natural resources are concerned.

The commission consists of Senators and Representatives, members of the executive departments, and public-spirited private citizens familiar with particular resources. It is wholly without funds, and it has therefore depended altogether on the public spirit of its members and the cooperation, which we were so glad to give, of the executive departments at Washington and in the several States, especially the scientific and statistical bureaus. I wish to take this opportunity to express, on behalf of the people of this country, my profound appreciation of the disinterested work—work so valuable that it could not be paid for adequately anyhow, and which, as a matter of fact, was not paid for at all, performed by the individuals in private life who have given so lavishly of their time and thought, and of their money, in forwarding this cause. This work has brought these scientific and statistical bureaus into closer and more effective cooperation than ever before, and for this reason the results will rank as by far the most useful statement of the national resources ever prepared in any country. Each bureau, without relaxing its regular work, has collected and summarized the results of its past work, and has contributed them to the commission. Having made acknowledgment to one set of men, I wish to make acknowledgment to another set of men, a special acknowledgment to the government servants, State and Nation, who have so cheerfully and successfully accepted and carried out this additional task; to the man behind the pen or the typewriter who worked extra hours, who gave up part of the holiday to which he was entitled; to his bureau chief, to his division chief, who did the same thing; to all of those who rendered a public service with no thought that it would ever be known outside that it had ever been rendered, I wish to express, on behalf of our people, my heartiest thanks. They have done a real service to the whole nation at the cost of great personal sacrifice of time and effort to themselves; and the best of it all was the admirable spirit of cooperation which characterized the whole work. They all worked together, and each was concerned, not in seeing what credit he would get out of the job, but with doing his part of the job well. That is pretty high praise, and it is a pleasant thing for an American President to be able to give it.

I am especially glad to welcome the cooperation of the States through their conservation commissions and otherwise. Such cooperation gives earnest of mutual assistance between States and nation, and mutual benefits to follow. Without it the great task of perpetuating the national welfare would succeed, if at all, with difficulty. If States and nation work for it together, all in their several fields, and all joining heartily where the field is common, we are certain of success in advance. We are concerned with the people's rights; if this means national rights, well and good; if it means States rights, well and good; we are for whatever serves the cause of the people's rights.

The national organizations concerned with natural resources, such as the great engineering societies, the National Rivers and Harbors Congress, which is now holding its fifth convention; the Southern Commercial Congress, also in session, which has made so excellent a beginning—all these and many others have joined in the work in a way to gladden the heart of every patriotic American. A special word is due the National Rivers and Harbors Congress. It is the one organization that is advocating a waterway policy and not a waterway project, and is national in its scope, for it represents practically all the friends of waterway improvement in the United States. The question of river and harbor improvements and the benefit that each will bring to the producer and consumer has, through its work, been favorably and prominently brought to the attention of the country. Prominent commercial organizations and men of character and influence throughout practically every section of the country are enlisted in the cause it represents. Its work being strictly national, and in no sense local or sectional, merits and should receive the support of our citizens.

I thank all these organizations. The results of the inventory of resources will be laid before the present conference by the National Conservation Commission. I shall not attempt to review these results further than to say that the more striking facts brought out at the conference last May are amply confirmed. These facts are sobering. No right-minded citizen would stop the proper use of our resources, but every good American must realize that national improvidence follows the same course and leads to the same end as personal improvidence—and no man is a good American if he does not think of future Americans, any more than a man is a good citizen if he does not think of his children's welfare, for there isn't any man whom we despise more than the man who has a good time himself and whose children pay for it. So with the nation. That nation is contemptible that riots in abundance by wasting the heritage it should leave to the citizens that are to come afterwards. Needless waste must stop. The time to deride or neglect the statements of experts and the teaching of the facts has gone by. The time to act on what we already know has arrived. Common prudence, common sense, and common business principles are applicable to national affairs just as they are to private affairs, and the time has come to apply them in dealing with the foundations of our prosperity.

I do not believe in hysteria or sensationalism in the press or anywhere else. I would not grow hysterical or sensational in describing our condition. But neither must we allow a false security, based on conditions long since passed away, to blind us, to prevent us from seeing the facts and applying common sense to the situation they disclose. The purpose of the inventory was and is to give the facts—not to create alarm, but to take stock of what we have, and so to lead to the necessary action for its preservation and increase. Our natural resources are so related that the use of one affects the use of all the others. This is especially true of our waterways. Every man, woman, and child within our borders has an interest in them through navigation, power, irrigation, or water supply, or through all four. Every man, woman, and child in the Union has his or her welfare vitally concerned with some phase, or with several phases, of the conservation of our water supply. We have neglected our waterways more than any other natural resource, and we must put an end to that neglect. The Inland Waterways Commission has told us how.

First, prepare a comprehensive plan for inland waterway development along the lines pointed out by the commission. Such a plan must consider every use of the waters; it must put the interests of all the people in advance of any private interests whatsoever. Gentlemen, you applaud that, but I want you to act on the principle that you are applauding, and you will find it a great deal harder than to applaud it, because, mind you, the special interests include not merely and not principally interests of special individuals but interests of special localities; and any of you who do not know what it is to try to get through a scheme for the general good that seems not to pay heed to the interests of a special locality have an eye-opening experience before you; and that whether you are engaged in trying to improve the right rivers without wasting your money in improving unnavigable creeks, or whether you are trying to get proper navy-yards properly supported instead of having the money wasted on navy-yards which have the one defect of being totally useless. I got some applause for that statement, but not very much really hearty applause from people who live by the creeks or near the navy-yards to which I allude. Now, gentlemen, seriously, remember that the chance to make the waterway improvement what it must be made lies in our resolutely refusing to pay heed to anything but the great common interest. If you dissipate the improvements throughout the country on the ground that each congressional district shall have its share, you had better abandon the project from the beginning. I want you to have a comprehensive plan formulated by a national commission, because I want to see that plan genuinely national in its scope, conceived in a spirit that will make it general for the use of the whole Union. That plan must consider every use of the waters, and its preparation should begin at once. We need to have a comprehensive plan. That does not mean that we should not begin the work now. Begin the plan. But there are certain pieces of work which we already know will fit into any right plan that is produced. For these pieces of work plans have already been approved. Our previous policy of procrastination, delay, and fitful and partial action has borne its perfect fruit. Our waterways are deserted, and in return for our vast expenditures we have to show the expenditure itself and no navigation. The people are ready for a change. Let us have it, and have it at once. If we can pay the cost from current revenue, let us do so; if not, let us issue bonds. I always favor paying out of the current revenue anything that we can properly pay. I am exceedingly proud of the fact that during the seven and a quarter years that I have been President we have had on the whole a net surplus of income over expenditure of about $100,000,000, in spite of the fact that we paid $50,000,000 outright for the Panama Canal; and during these seven and a quarter years we have reduced the interest-bearing debt, slightly reduced taxation, and have paid all the expenditures made necessary by the policies upon which we have embarked, while at the same time saving up on an average some $15,000,000 a year. A pretty good showing! I would not on any account go into the business of issuing bonds to pay for anything that was not of permanent and national good. I hope it will not be necessary in this case; but if it is necessary, then, as this is a great permanent enterprise for the permanent national good of our children, it is all right to issue bonds so that the enterprise may go ahead. I am glad you cheered enthusiastically, but I want you to be just as enthusiastic about disregarding local and special interests.

The work, therefore, should begin at once; but there must not be the slightest recklessness or waste of money. No work whatever should be undertaken that has not been thoroughly examined and fully approved by competent experts, and these competent experts do not look at things exactly as if they were enthusiastic citizens of the neighborhood. Above all, not one cent should be expended to satisfy special interests, whether of a business or of a locality, or promote any man's political fortune. This is too large a business to be handled in such a way. We must approach it from the point of view of the national interest, under the guidance of the wisest experts in engineering, in transportation, and in all the uses of our streams. Forests and waterways can not be separated in any successful treatment of either. Forest protection and river development must go hand in hand. The three things which should be done without any further delay are, therefore: First, to provide for a comprehensive waterway development; second, to begin at once on work already planned that will surely fit into the larger plan; third, to provide amply for forest protection against fire, against reckless cutting, against wanton or reckless destruction of all kinds, and as a prime incident of this third provision to secure without delay the Appalachian and White Mountain national forests.

ADDRESS OF GOVERNOR GEORGE E. CHAMBERLAIN, OF OREGON.

Mr. TAFT. I have the honor of presenting Governor Chamberlain, of Oregon, to continue the discussion.

Governor Chamberlain spoke as follows:

Mr. Chairman and gentlemen, on the 3d day of October, 1907, the Inland Waterways Commission, at a meeting on board the steamer *Col. A. Mackenzie*, the President of the United States being present and presiding, it was decided to call a conference on the general subject of the conservation of the natural resources of the nation. The commission thereupon prepared a formal letter to the President, giving their reasons for such conference, and asking him in case of concurrence in their views to issue a call for the same. The next day, in a magnificent address delivered by him to the Deep Waterway Convention at Memphis, the President announced his intention to call the conference, and on the 13th day of November he issued invitations to the governors of the States and Territories to meet at the White House May 13-15, 1908, the conferees to comprise in addition to the governors three advisers to be selected by each, the Senators and Representatives in the Sixtieth Congress, the members of the Inland Waterways Commission, and representatives of certain national organizations dealing with natural resources.

The conference was had at the appointed time and place and was largely and enthusiastically attended. Later, carrying out the purposes of the conference, the President appointed a National Conservation Commission, organized in four classes, to consider the resources of water, forestry, land, and mines, and invited the governors to appoint state commissions to consider and report upon the condition of the same resources in the several States and Territories. This meeting has been appointed for a conference of the national and state commissions, in order to assist in devising ways and means for future conservation of the natural resources of the country by appropriate legislation, national and state. The Oregon commission is here to-day, represented by the chairman, Mr. J. N. Teal, with a splendid report on the natural resources of our State, and I presume all the other States will be represented and reported upon.

I have been honored by an invitation to address you on behalf of the governors, and I have accepted with some reluctance, because I fully understand that the views of the executives of the different States may be so divergent with respect to the matters to be considered—the topography, climatic conditions, and needs of the commonwealths comprising the Union so unlike—that it would be impossible for me to voice their sentiments on a subject of such vast importance to the present and future welfare of the nation.

We are probably all agreed upon one point. Conservation of the natural resources is necessary to the well-being of our country, the protection of generations yet unborn, the perpetuation of our institutions, and cooperation on the part of state and federal authorities is essential to accomplish beneficial results. As to the means to be adopted to attain the ends desired, we may differ radically. In the outset, therefore, I disclaim any intention to be the mouthpiece of the executives of the different States in the suggestions I may make as to the steps which I believe are essential to bring about the greatest good for the greatest number. It was undoubtedly timely that the forestry and reclamation branches of the Federal Government first sounded a warning as to the wanton destruction of the forests and the resultant consequences of fuel famine, soil erosion, flood waters at certain seasons and at others an insufficient supply for domestic, industrial, irrigation, and even navigation purposes. It is questionable, indeed, if this warning, unsupported in other directions, would have been sufficient to arouse the people to vigorous action. But the distinguished President of the United States, with the energy which has characterized his whole official life, early took up the subject and on the 14th day of March, 1907, appointed the Inland Waterways Commission, not only to prepare and report upon a comprehensive plan for the improvement and control of the river systems of the United States, but upon the corelated subjects of forests and their conservation, soil erosion, and generally upon the control and uses of the navigable and other waters of the country for navigation and industrial purposes.

The conclusions reached by the forestry and reclamation departments were sustained and strengthened by the investigations of the Inland Waterways Commission. All were practically agreed that the navigability of our waterways and the maintenance of uniformity of depth and flow depended upon the tributary supply streams, and these in turn upon the protection of the forests along the watersheds and upper reaches of such tributary streams. In other words that the preservation of the forests, the distribution of water for irrigation, domestic, and industrial purposes, its uses for the generation of power, light, heat, and mining, and the navigability of the rivers were so corelated and interdependent that the consideration of means for the preservation of one meant the consideration of means for the preservation and protection of all.

The conference at the White House has gone into history as one most unique in every way, and it is hoped that much good will result therefrom. It may be safely said that even if it should fail to bring about united and harmonious action upon the part of all the States, it has sounded a warning as to the necessity of resource conservation and reproduction where possible, which will certainly be of lasting benefit.

The discussions which took place and the papers read at the conference were able, interesting, and instructive, covering in detail every subject allied with the natural resources of the country, and furnished most valuable information for the guidance of subsequent investigators. No particular recommendations, however, were made for legislation either by Congress or the state legislatures to safeguard and protect our resources. That duty will probably devolve upon the present conference of the national and state commissions, and it is to be hoped that both patriotism and wisdom may characterize the deliberations of the conferees here assembled, to the end that a course may be mapped out which will meet with the approval of the whole country.

From the earliest days of the Republic the public lands, agricultural and mineral, arid, and semiarid, the waters on and under the earth, and all the resources of sea and land have been given away with a most wanton and reckless prodigality, until much that is most valuable and essential to national strength has gone into individual or corporate ownership.

As a result, magnificent resources that should have remained under government control for the use and enjoyment of the whole people have been dissipated and uneconomically administered to the enrichment of the few and the impoverishment of the many. The forests of the country, on the mountains at the headwaters of many of the navigable streams, as well as in the valleys have been denuded until now the date can almost be named when, if present methods be pursued without reforestation, there must inevitably be a lumber famine with all that such a condition entails; the coal mines are being exhausted, with an ever-increasing fuel demand, natural oils and gases are being used extravagantly and wasted wantonly, as though the supply were inexhaustible; soil erosion is taking place so rapidly by the denudation of the forests that vast areas of agricultural lands are being washed into the navigable waterways, impairing the navigability of these important avenues of commerce; the increased and increasing demands for iron and steel seriously threaten the exhaustion of the mines; and until now no step has been taken to call a halt to wasteful extravagance or to safeguard to present and future generations the little of these resources that remains. I do not underestimate the creative and inventive genius of our people, but it is no answer to the charge of wasteful extravagance in the use of our magnificent resources to say that substitutes for them all may be found whenever the necessity arises. That is not the history of other countries and of other peoples who have ruthlessly squandered the gifts of a beneficent Providence.

A partial inventory was made and an account of stock taken at the last conference, and it would be out of place at this time to indulge in detail, because the national and state conservation commissions are now engaged in making a complete inventory of all natural resources.

The question, it seems to me, which ought to engage the attention of the present conference is, what policy ought to be adopted for the future with respect to the conservation of the natural resources of the country?

One of two policies must be adopted in order to succeed, and it must be either (1) national or (2) state.

Whatever policy is adopted, it must be entered upon with a vigorous determination, a strong hand, and under intelligent direction.

1. And first as to a national policy.

As to the authority and jurisdiction of the Federal Government over the undisposed-of portions of the public domain there can be no question. There the power of Congress is unquestionably supreme with respect to the soil, the mine, the forest, and the streams tributary to the navigable waterways and their use, certainly in so far as such use might interfere with navigation.

Again, the Federal Government, under the interstate-commerce clause of the Constitution, has jurisdiction over the navigable waterways of the country. About this, too, there can be no question.

In the exercise of jurisdiction over the navigable waterways, how far can Congress or the courts go in the matter of the control of streams which, though not navigable, are nevertheless tributary to the sources of supply, and so affect the uniformity of the flow of waters in the navigable highways?

In the case of The United States *v.* Rio Grande Dam and Irrigation Company (174 U. S., 690), the court discussed this question in connection with the appropriation of water for irrigation and other purposes as affecting the navigability of a river, and in the course of the opinion said:

> Although this power of changing the common-law rules as to streams within its dominion undoubtedly belongs to each State, yet two limitations must be recognized:
>
> First. That in the absence of specific authority from Congress a State can not by its legislation destroy the right of the United States as the owner of lands bordering on a stream to the continued flow of its waters, so far at least as may be necessary for the beneficial uses of the government property.
>
> Second. That it is limited by the superior powers of the General Government to secure the uninterrupted navigability of all navigable streams within the limits

> of the United States. In other words, the jurisdiction of the General Government over interstate commerce and its natural highways vests in that Government the right to take all needed measures to preserve the navigability of the navigable water courses of the country, even against any State action. It is true there have been frequent decisions recognizing the powers of the State, in the absence of congressional legislation, to assume control of even navigable waters within its limits to the extent of creating dams, booms, bridges, and other matters which operate as obstructions to navigability. The power of the State to thus legislate for the interests of its own citizens is conceded, and until in some way Congress asserts its superior power and the necessity of preserving the general interests of the people of all the States, it is assumed that State action, although involving temporarily an obstruction to free navigability of a stream, is not subject to challenge.

And again in the same case the court said:

> It does not follow that the courts would be justified in sustaining any proceeding by the Attorney-General to restrain any appropriation of the upper waters of a navigable stream. The question is always one of fact, whether such appropriation substantially interferes with the navigable capacity within the limits where navigation is a recognized fact. In the course of the argument this suggestion was made, and it seems to us not unworthy of note, as illustrating this thought.
>
> The Hudson River runs within the limits of the State of New York. It is a navigable stream, and a part of the navigable waters of the United States, so far at least as from Albany southward. One of the streams which flows into it and contributes to the volume of its waters is the Croton River, a nonnavigable stream. Its waters are taken by the State of New York for domestic uses in the city of New York. Unquestionably the State of New York has a right to appropriate its waters, and the United States may not question such appropriation, unless thereby the navigability of the Hudson be disturbed. On the other hand, if the State of New York should, even at a place above the limits of navigability, by appropriation for any domestic purposes, diminish the volume of waters, which, flowing into the Hudson, a navigable stream, to such an extent as to destroy its navigability, undoubtedly the jurisdiction of the National Government would arise and its power to restrain such appropriation be unquestioned; and within the purview of this section it would become the right of the Attorney-General to institute proceedings to restrain such appropriation.

Numerous other cases might be cited to show that Congress has not only jurisdiction of the navigable waterways, but over the tributary streams as well, so as to prevent their use to the detriment of the navigability of the rivers they supply, and can even resume control of waters appropriated by a State for domestic purposes to the destruction of the navigability of a stream.

If this power and jurisdiction be recognized, may it not be insisted that it is within the powers of Congress to enact a uniform code, not only to safeguard the waters tributary to the navigable waterways against such diversion or obstruction as may destroy navigation, but also to provide for the distribution of such waters for beneficial use in the reclamation of the arid and semiarid lands of the country? For surely the time will come, if it is not already at hand, when the appropriation and diversion of the waters of many of the nonnavigable waters of the country for purposes of irrigation and generation of power for industrial and other purposes will seriously impair, if not destroy, the navigability of streams emptying into the Mississippi, the Columbia, and other great rivers of the country.

My purpose in this discussion is to call attention to the powers which Congress unquestionably has, and to others which, in my opinion, it has as an incident to those expressly granted. If the position assumed is correct, Congress has jurisdiction over many of the most valuable resources of the country, and why may not a law be passed creating an interstate conservation commission, authorizing them to work in connection with the departments of Government now having jurisdiction over the public lands, the forests, navigation, reclamation, and kindred subjects; making appropriations for the purchase of deforested lands in the Appalachian Range and elsewhere, with authority to reforest them, empowering them to exercise the right of eminent domain in such cases as might be necessary; authorizing the adoption of rules for the distribution of the waters of all streams tributary to the navigable waterways, and particularly those which are interstate?

Such an act would vest in the National Government jurisdiction over by far the larger part of the work of resource conservation, and would create a central administrative system which would result in great and lasting good and be more effective than any other system.

But it may be asked, Why may not the States exercise the powers herein suggested as likely to be better performed by the National Government?

To this I answer:

First, the States, as a rule, do not seem disposed to act for the preservation of their natural resources, either with respect to the land owned by them or by the exercise of their police power. There are, however, some notable exceptions to this rule.

Second, even in cases where the States have legislated with reference to the subject of the distribution of waters, whether from interstate or intrastate streams, there is such a lack of uniformity in legislation, as well as in judicial interpretation, that it is difficult, if not impossible, to determine the rights of individual citizens.

It is well known how unpopular was the policy of national forest creation in its inception in all the States. The range user as well as the small settler along the edges of the forests had come to feel that he had a right by prescription to use as he saw fit the unsold portion of the public domain. I myself was of the number to oppose the policy, but that opposition was the result of the lack of information as to the corelation of water conservation, soil erosion, flood, and drought, and the uniform distribution of waters for reclamation of the semiarid regions of the West. The movement, I assure you, now meets my hearty approval.

The unpopularity of the forest reserve is gradually giving way to acquiescence and approval, and all opposition, I am sure, will vanish when the rules for its administration can assume the order and method of a code, and people come to understand better the objects and purposes underlying it all.

Who doubts for a moment that State effort along these lines would have entirely failed, and that but for the persistent, indomitable, and intelligent effort of Mr. Gifford Pinchot, who deserves a very warm place in the hearts of his countrymen, even national effort would have come to naught?

But the difficulties that beset state control can be better illustrated by reference to the distribution of waters for irrigation purposes, particularly where the rights of citizens of different States along the upper and lower stretches of interstate navigable waters and their tributaries are involved.

To the full enjoyment of these rights there should be a uniform code governing both the distribution and use of waters, and an administrative system that can reach across state lines and enforce by proper proceedings all rules and regulations.

The National Irrigation Congress, held at Boise, Idaho, in September, 1906, realizing the difficulties in the way of regulating the distribution of waters along such streams, appointed a committee of expert irrigationists to examine into the matter and report to the next congress. This was done at Sacramento, Cal., the next year, and the committee reported amongst other things as follows:

> If there is to be any protection of priorities across state lines it should be by federal administrative system, corresponding in character to that needed for the establishing and protection of rights within a State.
>
> While it is true in the administration of water rights upon interstate streams by different States the right of appeal to the federal courts exists, that remedy is expensive, slow, and unsatisfactory. A decision of a court, once rendered, remains fixed, and only settles the particular question involved in the case, while conditions surrounding irrigation on either side of the state line are constantly changing, and the use of water for irrigation rapidly growing.

While it is true that some of the States have adopted fairly good laws governing the distribution of water for irrigation and other purposes, yet even in these there is a lack of uniformity and a conflict of judicial interpretation. A few instances might serve to show the difficulties of an equitable adjudication of water rights on interstate streams. Bear River begins in Utah, flows into Wyoming, crosses again into Utah, returns to Wyoming, then into Idaho, and empties into Great Salt Lake. Lands are being irrigated from its waters in each of the States through which it flows, and each State has a different law.

Lesser Snake River crosses the boundary line between Colorado and Wyoming four times. Adjudications as to the rights of water users in Wyoming are not heeded in Colorado and vice versa, and there is no authoritative administrative system.

The Arkansas River is another instance. It rises in the Rocky Mountains, flows for 300 miles in Colorado, crosses into Kansas, traversing it for 310 miles, enters Oklahoma, and empties into the Mississippi on the eastern boundary of Arkansas. A suit was recently instituted by the State of Kansas against the State of Colorado to determine the rights of the citizens of the two States with respect to the waters of this river. It is safe to predict that the final determination in this suit can not and will not settle finally the rights of all the parties, and some sort of interstate regulation will eventually be necessary.

Other instances might be cited, but these are sufficient to illustrate the difficulty which besets state regulation and control of waters for irrigation and other purposes.

There are again other cases where a stream has its source in one State and its waters are used for irrigation and power purposes in another; the latter State has no power or authority, if the necessity should arise, to go into the former and construct storage reservoirs, no matter how valuable they might be. I would not for a moment be understood as claiming that Congress has any power, jurisdiction, or authority to disturb rights to water which have become vested through national or state laws.

On the contrary, I insist that such rights should be protected and will be promoted by the course here suggested for national control and administration. It is in the interest of these rights as well as for those yet to accrue that radical and immediate action should be taken. Who could have foreseen when the Constitution was adopted, or even a quarter of a century ago, the change that has taken place in the semiarid regions through the distribution of water? The beginning has only been made, and the prediction may safely be hazarded that, by the construction of dams and storage reservoirs and the enactment of laws for the proper distribution of water for reasonable and beneficial use, hundreds of thousands of acres of land which to-day are considered worthless will in the next quarter of a century be reclaimed and will furnish homes for thousands of sturdy men and women. It is to protect the men of the present day and age and their descendants in the enjoyment of their vested rights against the men of the future and those of the future against the unreasonable demands of the present that federal jurisdiction and legislation is here suggested. With the federal authorities in control of the undisposed of portions of the public domain in the several States, including the forests within the reserves, and the mines and minerals therein situate, the navigable waterways with their tributary streams both for controlling their use to maintain a uniform flow for the purposes of navigation and the distribution of waters for irrigation purposes as an incident to the maintenance of the navigability of the rivers, and in control as well of deforested areas owned and to be purchased for reforestation, there is no doubt that a policy of federal administration can be formulated that will do more for the preservation and protection of our natural resources than is possible to be done by the States acting separately. But cooperation by the States will still be necessary to accomplish the highest results, and in what I have suggested it is with the idea that such a movement would have the hearty cooperation of the state authorities.

Second, as to the policy of state administration.

I have pointed out some of the difficulties in the way of administration on the part of the States, of a portion at least, of our natural resources. There is no question but that federal administration and control would be more effective, and yet I realize that jealousies between the States themselves, and fear of federal encroachment upon the rights of the States, will make it difficult to agree upon a proper course of legislation. The work in hand is so important, not only to us of the present, but to future generations, that we ought to be able to lay aside all jealousies, and endeavor in a spirit of the loftiest patriotism to reason together and formulate if possible a policy of administration that is best for all.

Before the older States realized the value of their forests, their waterways, their mines and minerals, they had allowed all to slip from their hands and into private ownership. The same thing is now going on in the younger States and soon there will be left nothing to conserve of what we received from our forefathers as a magnificent heritage. Some course ought to be mapped out now for our future course and conduct.

If a national administrative system does not meet with approval, then let it be state. The conflicting interests of the States, the different conditions which prevail in the humid and semiarid regions, in soil, in climate, in topography, and finally in laws and judicial interpretation, will render the enactment of a uniform code a task of great difficulty. It can not be done here and now, but the initial steps may be taken for the appointment of commissioners from the different States to confer together and agree if possible upon a code for submission to the different state legislatures.

But whether the policy for the conservation of our resources be national or state, there should be hearty cooperation on the part of both the national and state governments, for without it all effort must fail.

To you gentlemen of the East, the North, and the South—to you gentlemen from every section of our country in control of the Federal Government, we of the West promise our best efforts in the work of conserving all the natural resources of all the States for the benefit of all the people.

ADDRESS OF MR. TAFT.

Mr. President, ladies, and gentlemen, the first thing I would like to say is in confirmation of what Governor Chamberlain has said as to the debt that the public owe to Mr. Gifford Pinchot. President Roosevelt and Mr. Pinchot have brought about an unprecedented condition of affairs. They have gone into the States and brought the governors here, and they have created by that very fact a public opinion and a public interest in this great subject that I think could have been created in no other way.

To Mr. Pinchot's energy, I am sure President Roosevelt can testify, and everyone can testify who has had anything to do with Mr. Pinchot in playing a part in the movement that he is conducting.

How many parts of the speeches that have been delivered Mr. Pinchot has written I am unable to testify for others. But I can say that when he desires your services you might as well surrender.

Unfortunately it was not given to me to be present at the meeting of the governors last May, and I did not have the benefit of the information which was so generously spread before those who were present at that feast of reason and flow of soul. I did hear from that conference one expression that it seemed to me was singularly apt, and that has come in for criticism since, and that is the twilight zone of federal jurisdiction, an expression which I think an admirably correct one for describing something that will certainly present itself in the working out of this problem.

The truth is that the overwhelming necessity presented by President Roosevelt in his inspiring address for our doing something to conserve our natural resources is going to put us to a new test of the practical character of our system of government. It is going to involve the question whether, with the changing conditions, with the closer relations, and the interdependence of the various parts of this country, our National Constitution will furnish the means of meeting that necessity. Now, I have no doubt that it will. I have no doubt that it will, because I see the effect of it already on Democratic minds.

If it is true, as doubtless it is, that the forests and their continuance have a very direct effect upon the uniform navigability of streams, then the right of the National Government to go into reforestation is not very far removed from a constitutional demonstration.

Another reason why the Constitution should be construed, without straining it, to give to the National Government as large powers as possible in this direction, is that the plan to meet the emergency must be a comprehensive plan. It must be a plan covering the entire country, and the financial resources of no State are sufficient to carry out the plan as it ought to be carried out. I quite agree that there will be many instances in which it will be impossible even for a Democrat converted to federalism to give us federal jurisdiction within the States, and therefore that it is necessary to have cooperation on the part of the States. But nothing could have made that more possible than to summon the chief executives of the States into such a novel conference as that which met last May and which is met again this month—not, my dear friends, that it was intended to set a fire under Congress, but only that the information should be widespread and come down to the people, not only through federal tributaries, but also through the chief executives of the States.

I had some notes that I was going to read, but the truth is they contained so many expert statements that I am afraid you might suspect their authorship, and so if you will excuse me from going into a civil-service examination on the subject of waterways and water and where it conceals itself and how it ought to be treated, I shall content myself only with the statement of my deep sympathy with this movement and with my purpose, should the electors of the various States hit upon a suitable candidate, to do everything I can to carry on the work so admirably begun and so wonderfully shown forth by President Roosevelt.

I can not take my seat either without speaking in as strong terms as possible of the value of Governor Chamberlain's paper, in discussing the really difficult constitutional questions that are presented and the liberal and judicial and nontraditional spirit in which he has treated them.

One more subject and I am done. I concur in full in what the President has said in respect to the necessity of carrying out projects completed in their plan and which will fit into the general plan, and also in what he has said about the issuing of bonds. While it is true, as he said so forcibly, that the man who does not remember his children is worse than an infidel, it is also true that where a system can be devised by which the children shall meet and pay their portion, there is no reason why these little fellows who are growing up should not have a burden provided for them that will keep them under proper self-restraint. Now, I have no compunctions on the subject of issuing bonds, if the debt which is to be contracted ought to be met by bonds. I think we can sometimes overdo the business of what ought to be distributed expenses out of current income. There might be a reason for taking off taxation and reducing the income and meeting the expenditure by bonds for what are proper permanent expenses; and sometimes it takes as much courage and involves as much real public interest to issue bonds for a purpose for which bonds ought to be used as it does to pay as we go. In other words, it is a mere question of economic policy, and the mere fear of a criticism that an administration has issued bonds ought not to prevent us from doing justice to ourselves and to posterity.

Ladies and gentlemen, if the real power behind the throne consents, I declare this meeting adjourned.

(Thereupon, at 5.15 o'clock p. m., the meeting adjourned until Wednesday morning at 10 o'clock.)

CONFERENCE SESSIONS.

WEDNESDAY MORNING, DECEMBER 9.

The Joint Conservation Conference was called to order at 10 o'clock a. m. in the Red Room of the New Willard Hotel by Chairman Gifford Pinchot.

The CHAIRMAN. Gentlemen, in calling together the first joint conference for the consideration of the conservation of the natural resources of this country, I have no statement to make further than to say it seems best for the National Conservation Commission to place before you at once, so that you may at the beginning be aware of its contents, the report which it has drafted for submission to the President. This report, since it goes to the President, is necessarily a confidential communication, and therefore no copies have been printed for circulation. It will be read to the conference, without objection, as the first order of business to-day. Governor Blanchard, of Louisiana, will read the report, but Doctor Van Hise has asked me to recognize him for a preliminary statement before Governor Blanchard begins the report.

Doctor VAN HISE. It seems to me the commission should have some information as to the manner in which this report has been prepared.

Last spring the executive committee held a session in Chicago at which various lines of investigation were discussed and laid out to be pursued during the summer. Advantage was taken of the fact that the President had directed the various scientific bureaus of Washington to cooperate with the commission and to furnish all necessary information. As a result of that direction on the part of the President, the commission called upon the various bureaus in Washington to make investigations of the various resources of the country, especially with reference to their amount, with reference to the rate of exploitation, the increase of exploitation, and to give estimates as to the probable time they would last, provided the future tendencies continued at the past rate.

Therefore, when the commission gathered together last week we had before us a series of papers, prepared mainly by the experts of the bureaus at Washington, but some of them also prepared in cooperation with the state organizations and with the various national associations.

During four days those data were presented to the commission. They constituted the base of the pyramid of which the report of the commission is the apex. In those reports are found the facts upon which the commission's findings are based. Without that base, it might be thought that the commission's report was not justified, but in this matter we ask suspension of judgment in case of doubt until you may see the data and the facts which these experts have presented to us as substantiating the conclusions which the commission has reached. It would not have been possible to have accomplished so much as has been done had it not been for the services of these experts, and indeed these papers, when published, will be the most important part of the report of the commission. They of course can not be read this morning—they will constitute a book when published—and yet they will furnish the basis on which States and citizens may act.

Now a report drawn up through one week of work, based upon such data as have been furnished the commission, will be necessarily imperfect, imperfect by omission as well as otherwise, but so far as it goes the commission think it is sound and they present it as a first approximation to an adequate statement of this subject, in the hope that it may advance this movement for conservation.

REPORT OF THE NATIONAL CONSERVATION COMMISSION.

The **CHAIRMAN**. Gentlemen, it gives me great pleasure to now introduce Governor Blanchard, of Louisiana, who will read the report to which Doctor Van Hise has just referred.

Governor **BLANCHARD**. Mr. Chairman and gentlemen, the report which I am about to read has been explained to you by Doctor Van Hise, and is a compilation of a vast amount of material in the way of inventory taking of the natural resources of our country which has been going on since the President appointed the National Conservation Commission in June of the present year. This report is the result of the indefatigable labors of the Conservation Commission and of the special commission appointed by it for the purpose of preparing the report itself.

[The report in full as read will be found on page 13.]

The **CHAIRMAN**. Gentlemen, the suggestion of the commission to this joint conference for the consideration of this material is that the specific subjects—minerals, lands, forests, and waters—should be presented to the joint conference either by the chairman of the section or some member of the section chosen by him. In the belief that that plan would meet with your approval, and acting on behalf of the commission, I have invited Senator Flint to present to you more in detail the subject of minerals. After his presentation, if that be the pleasure of the meeting, the matter will be open for general discussion, with the single qualification, if I may be allowed to make it on behalf of the conference, that the governors be given the right of way. After the governors have spoken, the discussion will be entirely open.

Senator **NEWLANDS**. Mr. Chairman, before this subject is entered upon I would like to make a suggestion regarding the question of inland waterways. In conversation with Senator Frye, who is chairman of the Committee on Commerce in the Senate, the committee which has jurisdiction over harbors and rivers, I inquired whether a hearing before that committee could be secured during this week, and he replied that he would be glad to meet the pleasure of the conference either upon Thursday or Friday of this week. I present the matter now, in order that this conference may take the proposition under consideration and come to some determination regarding it.

In this connection it may be well to state that the Inland Waterways Commission, which was appointed by the President over a year ago, or pretty nearly two years ago, is now a section of the National Conservation Commission, the chairman of that section being the Hon. Theodore E. Burton, chairman of the Rivers and Harbors Committee of the House. That commission, which is purely a commission appointed by the President without statutory sanction, simply in aid of his power to make recommendations to Congress regarding legislation, entered upon an inquiry and examination and visited the different sections of the country and inspected the main rivers of the country and made a general inquiry of the subject. Prior to their report I introduced in the Senate of the United States, in a tentative way, a bill based upon discussion already had in the commission, simply with a view of testing the sentiment of the country. Later on the report of the commission was made and was sent by the President to Congress.

This bill was referred to the Secretary of War for his opinion and to the Inland Waterways Commission for its opinion. The Secretary of War approved the main features of the bill, but made some suggestions which were intended to bring it more clearly within the constitutional sphere of national action. The Inland Waterways Commission also approved the main features of the bill. That bill was considered by a subcommittee of the Committee on Commerce in the Senate and was reported favorably to the full committee with certain amendments. The bill, I will state briefly, covered, first, a waterway fund of $50,000,000. Its second provision gave the President of the United States the power to cause investigations and surveys to be made, and, in aid of that power, to appoint a commission to be known as the "Inland Waterways Commission," which was to bring into coordination all the scientific surveys of the Government relating to water, including the various bureaus of reclamation, the Geological Survey, and other surveys. It then provided for the coordination of the national surveys and their collaboration in this work. It also provided for cooperation of the States and municipalities, and it provided that whenever the fund was diminished by expenditures to $25,000,000 a bond issue should be made to make up the deficiency, bringing the fund back to its original amount of $50,000,000. It also gave this commission, whenever a project was deemed feasible, the power to enter upon the work without further action of Congress.

This bill was amended in certain material particulars by the subcommittee. I will not take your time now by stating what these amendments were.

The bill was then considered in full committee, but as there was considerable difference of opinion it seemed clear that the bill could not be presented to the Senate in time for consideration at the last session. At the suggestion of the President I introduced a shorter bill providing simply for the creation of a commission without defining its powers beyond giving it the power of investigation and a small appropriation. That bill was favorably reported to the Senate by the Committee on Commerce, but unfortunately there was not time for its consideration in the closing days of Congress.

Now, I would suggest that public opinion, of course, operates powerfully upon Congress regarding these matters. These great bodies throughout the country make public opinion. Congress always follows public opinion when it is clearly ascertained upon any subject, and it seems to me it would be well, while this great and influential body of men is here, that its leading men should appeear before the Committee on Commerce in the Senate and give their views and the views of this body and the views of the various sections of the country regarding this important question and the importance of providing a sufficient fund and the importance of providing for immediate commencement and consecutive prosecution of this great work.

I would suggest that perhaps Friday morning would be the more convenient time, as this conference is to be in session Wednesday and Thursday, and that a committee be appointed by the conference for the purpose of presenting this matter before the Committee on Commerce in the Senate upon Friday, at 10.30 o'clock.

The CHAIRMAN. Gentlemen, you have heard Senator Newlands's motion—I take it to be a motion?

Senator NEWLANDS. I will make that motion; yes, sir.

The CHAIRMAN. How many members do you think should be appointed on that committee?

Senator NEWLANDS. Have you any suggestion to make, Mr. Pinchot?

The CHAIRMAN. The only suggestion I have to make is that if the Senate committee is willing, it might receive all those members of the conference who may be willing to attend on Friday morning, and that you, yourself, arrange for the presentation of the subject.

Governor BLANCHARD. If the chairman please, what is everybody's business is nobody's business. If you say any members of this conference who desire to go may go, nobody will feel specially an obligation upon himself to go. I think that the Senator from Nevada is correct in saying that there should be a committee appointed and that it be made the specific duty of that committee to attend that hearing and present these matters.

Senator NEWLANDS. I would move, then, that the conference, or as many as possibly can do so, attend the session of the Committee on Commerce at 10.30 o'clock Friday morning, and that a committee of such number as the chair deems advisable be appointed by him with a view to presenting this matter to the Committee on Commerce.

Mr. LAY. I would suggest to the chair that that motion be amended: That there be appointed on this committee a member from each State.

Senator NEWLANDS. I will accept that with this proviso: That the chairman have the power to add such others to that committee as he deems advisable.

Senator SMOOT. Mr. Chairman, it seems to me if we want to get the information before the committee of the Senate, the best way is for the chair to appoint say three men for the purpose of presenting the matter to that committee. That is what should be done. We want the information to be presented, but if one from every State here is appointed, with no one designated to present the matter, we are going absolutely unprepared. The Senate committee can not waste time. If you appoint three men for the presentation of the matter and let every representative attend who desires, you will have some result, but if it is not arranged in that way I do not believe you will accomplish anything.

Senator NEWLANDS. I accept that suggestion—that the committee shall be appointed by the chair, consisting of at least one representative from each State, and that the chair select from this committee three men who shall have charge of the duty of presenting the subject to the Committee on Commerce.

Senator SMOOT. I second the motion as amended.

(The motion was unanimously carried.)

The CHAIRMAN. The committee will be appointed at the earliest possible moment.

Without objection, I will now call upon Senator Flint to present the matter of minerals. I take pleasure now in introducting Senator Flint.

SENATOR FRANK P. FLINT, OF THE SECTION OF MINERALS, NATIONAL CONSERVATION COMMISSION.

Senator FLINT. Mr. Chairman and members, I find myself in the awkward position of not being informed that I was to present this subject until a very late hour last night, when there was a meeting of this section of the commission. I have attended the various meetings and listened to the various papers that have been prepared, and can only in a general way present the matter to you here to-day.

The report read by Governor Blanchard shows clearly what has been accomplished, not only by this section of the commission, but the entire commission, and as my time is very limited and I am able to remain here but ten minutes more, I will just call to your attention in a general way the points brought out at this hearing.

The first thing I have to suggest is this: That an inventory has been compiled of the mineral resources of the country, which is admitted to be not what we would like in the way of a definite statement of just what we have. What has impressed us more than anything else in connection with this inventory is the lack of knowledge that we have on this subject, the importance that this commission should be continued, and that we should have a thorough inventory of the mineral resources of the country.

The very fact that we are not able to present to you a definite statement of our mineral resources seems to me a complete answer to those who say that this commission should no longer exist.

Some of the startling facts brought out in this report as to the waste of gas, where the statement is made in the report of this commission that the gas is now escaping from wells, both oil and gas wells, that could be saved, is sufficient to light all the cities of the United States with inhabitants of over 100,000, are worthy of our very serious consideration. It seems hardly possible that this great waste is going on, and yet this is the report of this commission, which has been giving careful study to this subject.

In the matter of coal, the report has been made that our coal will last until the middle of the next century. The report also contains the statement of the enormous waste that is now going on with reference to coal. The waste in all minerals produced in the United States to-day, it is estimated, amounts to $1,000,000 a day. Of all the mineral produced in the United States, one-sixth is wasted. That is the estimate of this commission. Not only has there been a great waste in the minerals produced, but a great loss of life. Not only has the loss of life been great, but it has been far greater than in other countries in the same line of work, and the trouble seems to me to be a lack of harmony between the National Government and the States in the matter of regulations for the protection of life and the waste of property. There has been considerable talk about a twilight zone, which was mentioned yesterday by President-elect Taft, which seems to me all-important in the question of the minerals that we are producing in this country and also in the matter of the loss of life in these various mining enterprises.

Yesterday Mr. Mitchell, a member of the commission, stated, as he has stated a number of times in the public press, that in his opinion the people of this nation, and especially the laboring people, would gladly favor an advance in the price of coal, so that the waste would not go on as it has in the past, and so that all those human lives would not be lost in the mining of coal, and I think that is one of the things with reference to which this conference here assembled should take radical steps, in the way of resolutions, to see if we can not bring about such a condition that the lives, which are more important than the waste of property, shall be protected by legislation, both State and national.

Another matter which this report calls to your attention is the matter of title to mineral lands, the recommendations by the mining section and the land section being that there should be a threefold title, one where the timber would be cut off under certain arrangements with the Government; second, that the surface should be farmed; and, third, that the minerals should be taken out under regulations.

Now, the condition of affairs in the country, so far as the mining laws are concerned, is as follows:

We have three different schemes for obtaining title to mineral property, viz, the coal-land laws, the lode-claim laws, and the placer-mining laws. Under the placer-mining laws we know the great frauds committed in taking up timber lands in the West, but at the same time it is difficult to frame a law that will permit placer mining and at the same time not permit the placer miner to own the surface of the ground. In other words, in placer mining as it is in the West it is necessary to take the surface or we can not have a placer mine. It seems to me there are mining claims, such as oil claims, where they might have the surface of the ground retained and then passed to the settler for farming purposes and the right given to take the oil out at the same time. Our mining laws should be changed so as to permit the various kinds of minerals to be taken out where necessary, and at the same time have the conservation of the ground that it may be used for farming.

The matter of taking out oil is another matter to which our attention has been called. Oil has been taken from the ground in various parts of this country where a mining location was made and a line of oil wells was placed along the end of the claim and then wells pumped in that way, taking the oil out of the adjoining claim. That made necessary the proposition that the man on the adjoining claim should also put down his wells. The result of this was an overproduction of oil in that place, and the oil actually lost by being pumped into large tanks, not made of iron but simply dug in the ground; and in many instances it was allowed to go to waste.

In connection with oil, another recommendation of the commission is that the oil be put to a higher use than for fuel; that coal should be used for this purpose, and our belief is that the use of oil as a fuel in our engines is a waste of the material; that if it be necessary for the future of our supply of oil, it should be conserved and put to a higher use than we are now making of it.

The coal supply is estimated to last for another century; the iron supply until the middle of the present century. With iron the statement can be made that the estimate is based only upon the class of ore they are now mining. The lower grades of ore will probably be mined in the future, and the time for the exhaustion of our mineral resources is not as near as we would be led to believe by the mere statement that iron will be exhausted in a short period. It is simply a question of the class of iron we are now mining, and not a question of the lower grades that remain yet to be mined.

Another matter called to your attention by the report of this commission is phoshate rock. There will be several talks upon this subject, and this is one of great importance to this country for the reason that this is where the mining industry comes close to the farmer. Here we find different figures presented to this commission, showing that the phosphate rock will be exhausted, as to the known supply, in about twenty-five years, and that of this phosphate rock about 40 per cent is now being exported; and the result will be that in a very short time we will find ourselves in this country in a position where we will not have phosphate to use for the fertilization of our farms; and for that reason there should be resolutions adopted, in my opinion, by this commission and the governors here assembled, looking forward to regulation of the exporting of phosphate rock. That can be done by a conservation of the mines now owned by the Government of the United States containing this rock. This subject will be treated by a number of papers, I believe, and is one of great importance.

In the matter of the question of the loss of life, Mr. John Hays Hammond, whose advice and counsel this commission has been very fortunate in having, will speak. He has talked with Mr. Mitchell, and by reason of his experience he will be able to present that subject to you in detail.

The great trouble in dealing with this mineral section is that we have to cover this entire country. Here in the East we have simply a limitation of mining to coal. Then we come to the Middle West, where they have coal and oil, and then to the extreme West, where they have minerals of all kinds. It is hard for the people in the eastern part of the United States to realize the great difference that exists in the kind of mining that goes on in the West and in the Rocky Mountains as compared with that in the coal mines in the eastern part of the country, and no one in this country is better able to present that matter from all standpoints than Mr. Hammond, who has had more experience, not only in every part of this country, but throughout the world, than anyone I know of. I will ask him to speak during the morning on the subject of labor and the differences in conditions in mining operations in this country and in other countries, as well as comparing the operations in the eastern part of our own country with those in the western part of this country.

Mr. CUTTLE, of California. Mr. Chairman, in order that this conference may have a proper record of its proceedings, I move that a committee be appointed by the chair, to be denominated a committee on resolutions, to whom shall be referred all resolutions offered before this conference, such resolutions to be referred to such committee without debate.

(Motion duly seconded, put, and carried.)

The CHAIRMAN. I will announce the committee on resolutions at the afternoon session.

Is there any discussion on this subject by any governor present? The programme, which has been tentatively established—for, of course, that means this conference will modify it in any way it sees fit—provided for one-half day for the consideration of each of the subjects, and minerals is the subject for the opening session. Is there any discussion from any of the governors with reference to the subject of minerals?

A Delegate. We discuss minerals and we discuss the forests and we discuss waters, but now as to the means of getting this before the people—the propaganda and the manner of educating the people. How is that to be done?

The Chairman. The principal means is that the report of the Conservation Commission and of the June conference shall be disseminated through the Government.

Dr. William H. Black, of Missouri. May I inquire with reference to that point? Our commission in Missouri would like to have this information at a very early date.

The Chairman. That touches a point which the commission has felt keenly. The necessity for dissemination of this information at the very earliest possible moment is a serious one for our consideration. You gentlemen will understand, in the first place, this report must go to the President. It would not be proper to make it public until it goes to him and he sees fit to make it public. In other words, whatever is addressed to the President must be made public by the President, and while we have a very strong hope that the President will act in making it public immediately upon its receipt, that matter must be left to him. Any separate action which might be taken by this conference in the way of passage of resolutions which were not included in the formal report could be made public at once.

Unless there is immediate discussion the chair would suggest Mr. Hammond be called upon. I take pleasure in presenting to you Mr. John Hays Hammond.

MR. JOHN HAYS HAMMOND.

Mr. Hammond. Mr. Chairman, I hasten to relieve the apprehension of the audience, who are led by my friend Senator Flint to expect that it is my purpose to deal, as he has intimated, exhaustively with the subject of mining accidents. As a matter of fact, I have no available statistics to present upon this sudden invitation. Besides this, there is so much else of importance for discussion at this short session that I trust you will be satisfied with the general statement that I believe a very great necessity exists for improvements in the system of mining, with the view of minimizing the loss of life.

PROF. MARSTON TAYLOR BOGERT, PRESIDENT AMERICAN CHEMICAL SOCIETY.

It will be strange indeed if the science which deals with the ultimate constituents of our material universe, their combinations and transformations, could not offer any assistance in the solution of the problem as to how our natural resources may be conserved. It is chemistry that has determined the composition of those materials which make up the earth upon which we live, the atmosphere which surrounds it, and the heavenly bodies beyond. Chemistry studies the properties of the elements and their various compounds, and upon these fundamental data our industries rest.

The transformation of the raw material into the finished product consists either in changing its external form, as in wood and metal working, weaving, and the like, or there is involved a chemical change, as in metallurgy, fermentation industries, the manufacture of glass, soap, cement, chemicals, etc. Practically all of our manufacturing processes are therefore primarily either mechanical or chemical. In the production of a metal from its ores, or of indigo from coal tar, it is chemistry that points the way; and the more complex the problem the greater the dependence upon this science. In devising new processes and in the discovery of new and useful products, chemistry is again the pathfinder. The community is apt to overlook the extent and diversity of the services rendered by the chemist because of the quiet and unobtrusive way in which the work is carried out, and yet the statement in the report of the Twelfth Census of the United States is quite correct when it says that—

> Probably no science has done so much as chemistry in revealing the hidden possibilities of the wastes and by-products in manufactures. This science has been the most fruitful agent in the conversion of the refuse of manufacturing operations into products of industrial value. Chemistry is the intelligence departments of industry.

The measure of a country's appreciation of the value of chemistry in its material development, and the extent to which it utilizes this science in its industries, generally measure quite accurately the industrial progress and prosperity of that country. In no other country in the world has the value of chemistry to industry been so thoroughly understood and appreciated as in Germany. And in no other country of similar size and natural endowment have such remarkable advances in industrial development been recorded; and this, too, with steadily increasing economy in the utilization of the natural resources.

That our own Government realizes the importance of chemistry seems evident from the fact that six of our nine federal departments already maintain chemical laboratories, where they handle not only their own chemical work but also that of the Departments of State, Justice, and Post-Office, which as yet have no chemical laboratories.

Coming then to our mineral resources, in the first place, let it be kept clearly in mind that metallurgy is a branch of applied chemistry, as it is founded upon chemistry and engineering. In general it may be said that the seriousness of our mineral problem lies in the fact that these are resources that can not be renewed. It may be urged that as matter is indestructible, metals once won from their ores should not waste but accumulate. And this no doubt is partly true. It is not so with our fuels, however, for when our carbon is once burned to carbonic acid it is no longer available as fuel, until by the slow processes of vegetable life some of it is fixed in plants and gradually reduced through peat to coal again. Six times as much of our carbon is now locked up in mineral carbonates unavailable for fuel as we have in the form of coal.

The life of our mineral resources may be prolonged by the discovery of new supplies or satisfactory substitutes, by avoiding waste in mining and extracting ores, and the discovery of methods which will render low-grade or other ores available by a more complete utilization of the latent possibilities of the ore, including the recovery of all by-products, and by preventing loss of life and property from fires and explosions.

The chemist is helping in many of these lines. It is to him that we must usually turn for the production of satisfactory substitutes, for devising new processes, and for the utilization of by-products and wastes. It was the pioneer investigations of Bunsen and De Faur which pointed the way for the use of furnace gases in preheating and in other directions, such, for example, as the recent commercial manufacture of formic and oxalic acids from the carbon monoxide present in generator gas. In smelting operations the chemist must analyze the raw materials—ore, coke, limestone, etc., the intermediate products—pig iron, if steel is to be made, and the final products, including the furnace gases and slag. Without the explosives of the chemist, modern mining, as well as most great engineering works, would be impossible. After the precious metals have been extracted it is powder which stands guard over them as it does over all the accumulated wealth and property of this and other nations. On the other hand, a chemist, Sir Humphrey Davy, by his invention of the safety lamp, has done more than anyone else to protect the miners from explosions. It is worth noting that the authorities did not appeal to a chemist until all suggested engineering methods had proven powerless to avert the terrible "firing" of the mines. The new sodium dioxide compound, "oxone," may prove of value in mine accidents, for it absorbs carbonic acid with liberation of oxygen. The oxygen upon which rescuers now depend is also the result of the skill of the chemist.

At one time the waste in the oil business was enormous, as only the kerosene was saved. Now, with the exception of occasional fires and the relatively small amount sprayed into the air with escaping natural gas, and those regions where the oil is wasted by seepage from earth pits, there is very much less lost, for chemistry has not only shown how a greater yield of kerosene may be obtained, but also how all the by-products, gas, gasoline, naphtha, lubricating oils, paraffin, vaseline, coke, and so on, may be saved with considerable financial profit. Certain of these distillates are used for the production of high candlepower illumination, as in the Pintsch and Blau gas processes. Rapid development in the use of gasoline engines has developed an enormous demand for this petroleum fraction. The most promising substitutes for gasoline appear to be alcohol and the benzole from by-product coke ovens. The former of these, although giving much higher efficiency as a fuel, is still too expensive to compete with gasoline except in special cases. The latter, as our number of by-product coke ovens increases, is likely to play a more prominent part in this field.

In 1907 over 40,000,000 tons of coke, valued at nearly $112,000,000, were produced from about 62,000,000 tons of coal. Only 5,500,000 tons of this, or less than 14 per cent, was obtained in by-product ovens. About 54,500,000 tons of coal were coked in beehive ovens. This involved a waste of 148,000,000,000 cubic feet of gas, worth $22,000,000; 450,000 tons of ammonium sulphate, worth a similar amount, and nearly 400,000,000 gallons of tar, worth $9,000,000. The gases evolved in coke ovens have high calorific power. Dantin estimates that in modern ovens only 65 per cent of this is necessary to effect the carbonization. The remaining 35 per cent amounts to about 3,700 cubic feet of gas, equivalent to 420,000 calories, per ton of coke produced. As a gas engine of 1,000 kilowatt power absorbs about 3,600 calories per kilowatt, the power wasted in beehive coking amounts to over 4,000,000,000 kilowatts, or about 3,000,000,000 horsepower. We are therefore wasting enough power to establish a great manufacturing center, enough ammonium sulphate to fertilize thousands of acres, enough creosote to preserve our timber, and enough pitch and tar to roof our houses and briquette our slag and waste coal. Lignites have been found to give not only an excellent yield of gas, but also tar, oils, paraffin, and other valuable by-products. It has recently been claimed that 1 ton of dried peat can be made to yield 162 liters of pure alcohol and about 66 pounds of pure ammonium sulphate.

In 1907, 4,000,000 tons of coal were consumed in the production of 34,000,000,000 cubic feet of coal gas for heating and illumination, worth $36,000,000, in addition to over 100,000,000,000 cubic feet of water and oil gas, worth $90,000,000, or $126,000,000 worth all told.

The value of coal to the consumer depends upon its heating power, the percentage of water it contains, the amount and character of its ash and of the clinker formed, and how extensively it corrodes the grate bars. For an authoritative answer to these and similar questions, the chemist must be consulted.

The composition of furnace and flue gases has been determined by chemical analysis in smelting and other industries, and by the utilization of these gases for preheating and for the generation of power, the amount of coal consumed has been reduced, and in addition valuable by-product recovered. In gas illumination the invention of the Welsbach mantle has greatly increased the amount of light obtainable from a given weight of coal, and has correspondingly reduced the drain upon our coal resources. The conversion of carbon into acetylene through calcium carbide should also be mentioned.

As iron, according to Clarke, composes 4½ per cent of our lithosphere, the chances of our discovering other important deposits of iron ore seem far better than in the case of other metals or of coal. The development of iron alloys is a most promising field and among these we may find satisfactory substitutes for other metals now more seriously threatened with exhaustion. The production of ferrosilicon may render available certain siliceous ores hitherto regarded as unworkable.

The chief use of iron is in the construction of railroads and of buildings. In building operations concrete is helping, not only as a substitute for iron and steel, but also as a protective covering for metallic pillars, girders, and the like. The iron and steel industry rests mainly upon chemistry and is under chemical control at every point. The production of steel by the Bessemer process depends upon the combustion of the carbon and silicon of the pig iron, the heat of combustion serving to maintain the mass molten. By the utilization of what was formerly the waste heat of blast furnaces to raise steam for the blowing engines and to preheat the blast, the amount of coal necessary to produce 1 ton of pig iron is only one-quarter what it was.

The slags are now largely used for the production of cement and concrete, as fireproof packing for steam pipes, and so forth, as ballast for railroad tracks or macadamizing highways, and for building purposes, as slag brick, slag blocks, etc., while those rich in phosphorus, as from the Thomas-Gilchrist process, are extensively employed in fertilizers. In the words of James Douglas, "When all the volatile products of the blast furnace are deprived of their heat-giving property and their chemical constituents, and with the slags, as well as the metal, have returned their heat to man instead of to the atmosphere, and the slag itself has been turned into cement or some other useful article, it will be a question as to whether the pig iron is the principal object of manufacture or one of the by-products."

The safety and comfort of travel on our railroads depends in large measure upon the skill of the chemist in testing the character of the materials employed in their construction and operation. It may be only a delay from a hot box, due perhaps to a poor quality of lubricant, or it may be a disaster from the failure of a signal or headlight at a critical moment, or a breaking of an axle or locomotive part, because of steel brittle from impurities.

Chemistry has played a prominent part in copper metallurgy. The matte is now bessemerized and 70 per cent of our total product is refined electrolytically. The avoidable waste in mining copper, zinc, lead, silver, and many other metals is estimated as at least 30 per cent. But the values now locked up in the Arizona slags, the Comstock slimes, and the Anaconda tailings will sooner or later be recovered by chemistry.

Chemistry has finally pointed the way by which aluminum may be obtained cheaply and in large amount from its ores. Last year our consumption of aluminum was 8,500 tons, worth $5,000,000, the world's production for 1907 being estimated at 20,000 tons. The commercial utilization of aluminum and its alloys is writing a new chapter in our mineral industry. To appreciate what this development in aluminum means it should be recalled that the total supply of it is nearly twice as great as of iron and about eight hundred times that of copper. Aluminum is already replacing copper for certain electrical purposes. A large part of the power now generated at Niagara Falls is distributed through aluminum alloy cables. It is also used for automobile castings, for air-ship construction, and for utensils of various kinds. The use of finely divided aluminum in Goldschmidt's "thermit" process of welding and casting is an important application of one of the chemical properties of aluminum.

A good example of the economy often accomplished by chemical investigation and discovery is furnished in the case of ultramarine. Many years ago, when this was made by powdering the mineral lapis lazuli, it sold for more than its weight in gold. Now that the chemist has discovered how to make the same material from such cheap substances as kaolin, sodium sulphate and carbonate, charcoal, sulphur and rosin, the price is only a few cents per pound.

In the field of the precious metals chemistry has contributed, among other things, the cyanide and chlorination processes, through which formerly rejected low-grade ores and residues have been compelled to give up their gold. The gold production of the world between 1851 and 1907 was three times that produced between 1493 and 1850. The value of our specie, upon which every commercial transaction rests, is determined by the chemists, while the green ink used in printing our bank notes, and to which they owe the name of "greenbacks," was invented by a former president of the American Chemical Society, Dr. T. Sterry Hunt. The chemist lets nothing escape unsearched. The sweepings from mints and from the shops of workers in precious metals, as well as the water in which the workmen wash their hands, are all made to relinquish the gold or silver they contain. Even waste photographic solutions must disgorge their silver before they are released. The invention of electroplating led to the use of plated articles instead of solid ware, and thus reduced somewhat the drain upon certain of our mineral resources. The supply of platinum has been for years so limited that the price has ranged high. Chemistry has now put on the market vessels of transparent and opaque quartz, which seem likely to replace platinum for some chemical purposes.

Many other instances might be cited where chemistry has made important contributions to the economic utilization of our mineral resources, such as the carbonyl processes of Mond, for example. But there is still much to be done in improving the present wasteful methods of smelting certain of our ores, and we may look for great advances in this direction through the rapidly developing and most promising field of electro-metallurgy.

Of the various factors upon which the success of this conservation movement depends, none, in my estimation, is more important than that of awakening the producer and manufacturer to a proper realization of the value of science to our industries.

MR. A. W. DAMON, VICE-PRESIDENT OF THE NATIONAL BOARD OF FIRE UNDERWRITERS.

Mr. Chairman and fellow-conferees, it was with unusual gratification that the officers and executive committee of the National Board of Fire Underwriters, in session on the 3d instant, received through your chairman the invitation to take part in this conference. The chairman's intimation that the appointment of a committee representing the National Board of Fire Underwriters would be acceptable was at once acted upon, and the undersigned were named as such committee. We desire to express our appreciation of the honor of a representation here, and to assure you of our interest in the great work you have undertaken and in which the organization we represent will be glad to cooperate to such an extent as may properly be within its province.

In considering the waste of the national resources we can not fail to have in mind, as underwriters, the vast destruction of values by fire year by year in the United States. Your commission has admirably divided itself into sections to take cognizance of the entire subject in a fourfold view, "waters," "forests," "lands," and "minerals," indicating the intention of broad and thorough treatment. We could have desired that the diagnosis should have proceeded a step further and added "fire" as a fifth division, and we trust that what follows will make clear the desirability of some specific treatment of this branch of the subject.

The annual fire waste in the United States for the last four years was $1,257,716,955, or an average annual loss of over $251,000,000. This is a daily average loss of $689,160. It is true this period includes the San Francisco and Baltimore fires. Extending the period to ten years, the loss was $2,029,734,345, giving an average annual loss of $202,793,434, or an average daily loss of over half a million dollars ($556,091). This waste is an absolute loss of the wealth of the country. The property value destroyed by fire is gone beyond recovery. Insurance only shifts the distribution of the loss. An irrecoverable loss it still remains.

If this enormous waste and drain were unavoidable, this committee would have no mission nor function here; but much the larger portion of this loss of property is preventable. The irrefutable evidence of this is the extraordinary difference in the fire waste of European countries and the United States.

From reports of United States consuls it has been shown by our committee on statistics that the loss in six European countries for a period of five years was 33 cents per capita. The loss in the United States for the five years ending with 1907 was $3.02 per capita, nearly ten times as much.

The result in 30 foreign cities gave a per capita loss of 61 cents, as against $3.10 in the five years' average of 252 cities in the United States.

Taking the number of fires to each 1,000 population in the same cities, our committee on statistics found it to be 4.05 in the American cities, as against 0.86 for those of Europe, showing also that, in point of frequency, fires here are far in excess of those abroad.

It is to be borne in mind that the direct fire loss is not the only waste of resources—owing to the greater frequency of fires in the United States and their greater destructiveness, more expensive fire-extinguishing facilities and apparatus must be maintained here.

We may add that it has been stated that as many as 7,000 lives have been lost by fires in the United States in a single year.

The excessive difference between the fire waste of European countries and that of the United States is caused principally by—

First. The difference in the point of view and the responsibility of the inhabitants of Europe and those of the United States.

Second. The difference in the construction of buildings.

Third. The difference in the regulations governing hazards and hazardous materials and conditions, and in the enforcement of such regulations.

Referring to the first-mentioned cause of difference it may be remarked that in a portion of Europe a landlord is responsible to his tenants and neighbors for any fire loss due to his negligence, and tenants are responsible to the landlord and to their neighbors for any loss due to their negligence. In this country a whole city might be destroyed by the unmitigated carelessness of some person, and there would not be the slightest penalty incurred. In Europe wastefulness is generally viewed as indefensible and a person who has a fire is regarded in an unfriendly light, since he has endangered his neighbor's property and comfort. In this country everybody is permitted to endanger his own and his neighbor's property almost ad libitum, either by the absence of wholesome regulating ordinances or by their nonenforcement. The reckless wastefulness of our people is nowhere more apparent than in the unnecessary fire drain on their resources. Our people appear to have a very erroneous idea of fire insurance and to think that insurance payments recreate destroyed values; whereas the fact is that insurance companies are in a sense tax collectors and distributers of such taxes among those suffering loss by fire.

The difference in the ideas of thrift, in the view of responsibility to neighbors, in the perception of the real meaning of fire loss or waste, are the cause of the larger number of fires per capita in the United States, and perhaps of the larger loss per capita.

The next principal cause of our excessive fire waste is our faulty construction. Our buildings as a whole are more flimsily constructed and are larger and higher than in the countries of Europe, where the building laws are safer and better enforced.

Our statement of the third cause of the excessive fire loss in the United States, namely, the lack of regulations to govern hazards, is self-explanatory and need not be amplified in this brief address.

The National Board of Fire Underwriters, which this committee represents, devotes its energies and activities to the reduction of the fire waste and the safeguarding of property and life, and has nothing to do with rates of premium. It confines itself to matters in which fire insurance companies have a common interest and most of which also deeply concern the public.

Thus, through a committee on fire prevention, commanding the services of a corps of engineers, the cities of the country are systematically inspected by the National Board of Fire Underwriters with a view of pointing out defects in water supplies and fire department equipments, and copies of these reports, with our recommendations for improvements, are presented for the free use of the municipalities; an extensive laboratory plant is supported for the purpose of testing materials and devices of a hazardous nature entering into the problems of fire protection; a model building code has been adopted, 10,000 copies of which have been distributed to cities and towns in the United States; an arson fund is subscribed, from which over a million dollars in rewards have been offered for the conviction of incendiaries; nearly half a million of standard rules and lists of hazardous and protective devices and materials were during the past year alone circulated to the public free of charge; hundreds of thousands of copies of the rules to regulate electric installations are annually distributed, and in every way possible we have endeavored to create a sentiment which should tend to place some check upon the constantly increasing destruction of values by fire.

The committee believes that the present fire waste in this country is an unnecessary national calamity, and that to reduce it it is essential—

First. That the public should be brought to understand that property destroyed by fire is gone forever, and is not replaced by the distribution of insurance, which is a tax collected for the purpose.

Second. That the States severally adopt and enforce a building code which shall require a high type of safe construction, essentially following the code of the National Board of Fire Underwriters.

Third. That municipalities adopt ordinances governing the use and keeping of explosives, especially inflammable commodities and other special hazards, such as electric wiring, the storing of refuse, waste, packing material, etc., in buildings, yards, or area ways, and see to the enforcement of such ordinances.

Fourth. That the States severally establish and support the office of fire marshal and confer on the fire marshal by law the right to examine, under oath, and enter premises and to make arrests, making it the duty of such officer to examine into the cause and origin of all fires, and when crime has been committed requiring the facts to be submitted to the grand jury or proper indicting body.

Fifth. That in all cities there be a paid, well-disciplined, nonpolitical fire department, adequately equipped with modern apparatus.

Sixth. That an adequate water system, with proper distribution and pressure, be installed and maintained. In the larger cities a separate high-pressure water system for fire extinguishment is an absolute necessity to diminish the extreme imminence of general conflagration.

If the commission can excite the interest of the people, the States and municipalities in the unnecessary and indefensible waste by fire in this country and the remedial measures herein recommended, they may hope to have accomplished something toward diminishing, if not entirely removing, this national misfortune.

There are already signs of an awakening public opinion on this subject. Many of the governors have mentioned it in their messages to legislatures; the insurance commissioners of the various States have frequently pointed it out and urged action, and recently the public press has shown an inclination to print articles on the subject. A law is now upon the statute book in Ohio requiring textbooks to be read in the schools on the "Dangers and chemistry of fires."

As long ago as 1892 a committee of this board addressed the President of the United States on the destruction of life and property by fire. As was expected, it appeared to him a matter for state rather than national legislation; and possibly this direction may now be given it through the connection of the governors of States with your commission. With state and municipal authorities working together many of the reforms herein suggested can without question be effected, and if this presentation should result in accomplishing this, the desire of the interest we represent would to that extent be fulfilled and the welfare and prosperity of the country measurably enhanced.

This report is submitted by the special committee of the National Board of Fire Underwriters, composed of J. Montgomery Hare, A. W. Damon, C. G. Smith, George W. Babb, R. M. Bissell, R. Dale Benson, R. Emory Warfield.

MR. THOMAS F. WALSH, PRESIDENT TRANS-MISSISSIPPI COMMERCIAL CONGRESS.

Mr. Chairman, ladies, and gentlemen, the object which calls you together, the conserving of our national resources, is a question which deeply affects our nation's future. It is the part of wisdom for nations as well as individuals to pause and look the field over, take stock, so to speak, and try to see whither we are drifting. This is not only wise as regards our national resources, but is equally so of all other channels through which wealth is created, and even more so in the sphere of ethics. Thanks to a beneficent Providence, no nation has ever made more rapid progress in the creation of wealth, and, what is of greater importance, in the uplifting and bettering of humanity, than the one to which we owe loving allegiance.

In developing and creating our great wealth, it became necessary to call freely upon our natural resources. Prodigal waste went hand in hand with use until their consumption and destruction—for it is a sad fact that we destroy more than we use—became great. Sounding the alarm and submitting the question to an intelligent and truly representative body like yours of how to stop waste and conserve these natural resources was one of the wisest of President Roosevelt's many wise acts.

In reviewing the past we must not forget that conditions have materially changed. Much that we condemn to-day was regarded as lawful and right—of sheer necessity in years past. As an illustration, take the consumption of timber. The West never could have been settled without railroads. When these railroads were projected they were looked upon as hazardous ventures, and proved so for their promoters in many cases. In the early days of railroad building the Government gave help in many ways, permitting the use of timber and ties from the forests in their construction. But the end surely justified the means.

The same wise course was followed by the Government in the field of mining. I remember being in Leadville during the winter of 1878–79. The rush to that great camp had commenced. The population increased almost over night from a few hundreds to many thousands. The winter was unusually severe, and as most of the population lived in tents the death rate from exposure and pneumonia was something appalling. The rush continued until the population increased to 30,000. Shelter had to be provided for this great army of human beings. The magnificent forests that spread for miles in every direction from the town, even to the mountain slope, had to be sacrificed to house and shelter them. When comfortable homes were established, the sickness and death rate dropped to normal. Here, as with the railroads, the end justified the means. Leadville has made permanent homes for thousands of our citizens and has enriched the country by hundreds of millions of dollars. It is one of the great productive mining camps of the world to-day. It may be said in passing that if we had had a law in force at that time similar to the laws of France, requiring the planting of a tree for every one cut down, the restoration of those beautiful forests would be almost complete by this time.

The same wise and liberal policy was extended by our Government in the building of homesteads, villages, and towns on agricultural lands and in the development of coal and iron mines. The rapid growth and development of our country was in a great measure due to the encouragement and assistance extended to infant industries by our National Government.

We are apt to bewail the great consumption of national resources, forgetting the magnificent permanent assets which we have to show for it. Trees have been put to better use in sheltering human life; coal and iron has been used in changing our land from desert conditions to teeming industrial and educational activities. Nor should we forget the sturdy pioneers of our civilization and the dangers and difficulties that they had to meet and surmount.

Now, however, the time has come to call a halt to lavish prodigality in giving away the people's inheritance. The time has come to stop giving away the public domain and to devise ways and means to husband our resources. To this end there are two courses to be pursued—one is arrestation, the other development. These should go hand in hand, for one helps the other. By arrestation I mean the stoppage of the terrible wastes that are going on in the mining and using of mineral fuels, and to some extent in other materials.

To preserve public lands for agricultural purposes, for actual settlers, we must stop the awful destruction of forests by fires and prevent the acquisition of vasts tracts by greedy corporations and individuals. Let us not forget this fundamental truth, that our welfare as a nation depends upon the justice and consideration which we show for the rights of the masses. This is a truth which the rich and well-to-do should take to heart. Instead of keeping aloof from public interests and exercise of the rights of citizenship as they too often do, they should take personal share in the affairs of government and become the initiators in all great movements that aim to make life easier, happier, and better for those less fortunate than themselves, even though this lays an additional tax upon their fortunes.

The other course, which I believe we should pursue, is that of development. Development is the greatest of all conservers. It creates and brings new wealth into activity. That man is the highest kind of philanthropist who inaugurates a new and honestly conducted industry which gives steady employment to many, with good wages and just treatment. The miner who discovers hidden treasure and causes it to be added to the wealth of the nation is a public benefactor.

The reclamation of the desert wastes, the drainage of miasmic swamps, and the utilizing of their stored fertility for the support of human life in comfortable independence are the highest and best forms of conservation.

Development creates wealth, and wealth distributed to the widest possible extent and wisely used by its possessors is one of the greatest of blessings to a nation.

This development should be carried on by the Government whenever it can judiciously do so. Individuals and corporations should receive encouragement and fair treatment from both the Government and people. Although much has been accomplished in the past, there is much, very much, to be done in the years to come to keep up our established rate of progress and to meet the pressing needs of our rapidly growing population.

Well-directed development will put all of our idle powers to work. It will utilize waters that are now going to waste, and discover and bring to light new means for saving in the consumption of and the husbanding of our resources. If electricity and heat could be drawn direct from nature's storehouse; if the air we breathe, one of the greatest forces, and one of the most pliant, ductile, and efficient for all the uses of man, could be compressed by and through itself with compensating results—in a word, if nature's materials could be used without waste, these natural blessings would be useful to man in many ways now undreamed of until the end of time. Considering what human intelligence has accomplished, this is not a mere vision.

In the sphere of mining there is much that development can accomplish which will lead to conservation. It is only recently that the world has awakened to the facts about the rare minerals. What little we know of radium leads us to believe that it possesses perpetuality of power, light, and heat. To what extent the production of this miraculous mineral may aid in this conservation is a fascinating field of speculation. The ore, by the way, from which this mineral was first extracted by Madam Curée came from a mine in Colorado, yet no atom of it has ever been produced in this country. The uranium ore that has been and is now produced from this same mine is all shipped to Germany.

Vanadium is another of the rare minerals the development of which will accomplish a wonderful conservation. It is the greatest alloy ever found for the making of steel. Its use will prolong the life of steel to many times what it is now. Here again, because of apathy, ignorance, and the lack of a governmental institution of guidance, we do not produce one pound of this valuable mineral that would do so much to husband our iron resources.

Gentlemen of the conservation board, a majority of your labors will lie in the field of mining. You will not proceed far before you will find that whilst our good Government has been generous toward all the other great activities of our national life it has been strangely neglectful toward giving a helping hand to what is in many respects the greatest of all industries.

For instance, in the field of agriculture that grand man who presides over its industries has linked science to the plow. You will find a young man at the head of the Forestry Bureau who, filled with patriotic devotion, is bringing science and energy to her aid. The Geological, Reclamation, and Weather bureaus are established on high principles and are rendering great scientific service. This is true of all other departments except that of operative mining, which receives no direct aid of any kind from the National Government.

For development and conservation of our mineral resources two governmental institutes for research are necessary—one for the baser and one for the precious minerals. These should be equipped with every modern appliance and managed by a small, compact force of the best experts and scientists obtainable. These institutes should be located in fields of active mining—one, say, in Pennsylvania and the other in Colorado. They should lead, direct, and instruct in the best methods of saving life, arresting the terrible destruction and waste now going on. They should give reliable data and information for finding and treating new minerals.

The need of such institutes has been forcibly shown recently, when our Government had to borrow scientists from other countries to solve the causes of the terrific explosions in coal mines, with the horrifying loss of life. You, too, will soon see the need of such institutes to go to in your work for information and advice.

Gentlemen, I have taken up much of your time. I ask you not to throw a blanket of sleepy inactivity over these questions of great national importance. Shut out the lawbreaker and the grafter, but encourage the prospector, the homesteader, and the honest investor. Conserve the people's rights. Be just to the present, but do not forget the future. Stand for the people and make them your allies in accomplishing the good work which you have undertaken.

In closing let me express my appreciation for the heads of our departments and their assistants. I know many of them intimately, and believe that no government receives more faithful service than ours.

It has become a good deal of a habit for certain classes to hurl criticism at public men and corporations regardless of whether they are trying to do their duty or not. Honesty and dishonesty are often but the reflex of the status of the body politic. It rests with the masses to make your task easier. It is the people who can create public sentiment which will not only conserve our national resources but, what is more dear to every lover of his country, uplift and improve the standard of that priceless heritage, American citizenship.

The **Chairman**. When I said the governors would be given the right of way I expected they would take it, but they are so modest it seems I must call upon them. There are two governors in this room interested in this matter—Governor Johnson, of Minnesota, and Governor Smith, of Georgia. I will call upon Governor Johnson for an address upon the subject of minerals.

GOVERNOR JOHN A. JOHNSON, OF MINNESOTA.

Mr. Chairman and gentlemen, I am at quite a loss to know exactly how to discuss this or any other question identified with this movement. I certainly am not in a position to discuss the matter of mineralogy or mining from a technical standpoint, either as to the matter of waste or its chemistry or any other particular feature of it. If I were to say anything at all it would be to take rather an optimistic view of the situation so far as the matter of iron mining is concerned. It seemed to me, though, as I listened to the discussions of mining, both at this conference and the one held last May at the White House, that probably we got the pessimistic opinion in our heads somehow that within a very short space of time the iron resources of the country are going to be entirely exhausted. I am quite sure that is not exactly the case and that there is no immediate danger of our running out of iron. I remember in May Mr. Carnegie read a very delightful and very able paper at the White House, in which he said that the Lake Superior country, or particularly that portion of it located in Minnesota, where they originally believed they had five or six million tons of iron ore, had now, they were quite certain, a billion and a half tons of iron ore. The statisticians who are going to present figures here later during this meeting have now items from the Oliver Iron Mining Company, an institution to which Mr. Carnegie is related in at least a very small way—the Federal Steel Company—estimating now from measurement made through the diamond-drill process, that they have two and a half billion tons of ore. If the product has increased a billion tons within a year and the production has decreased from 42,000,000 tons to 26,000,000 tons in the same length of time in the same territory, it seems to me we are going to have too much iron ore in the future. At least the press so far has put too much iron in the souls of Americans because of some of the conditions which obtain.

I am gratified to be able to bring to you—and I am not here to advertise Minnesota especially—my suggestion that we are sufficiently conceited in Minnesota to think we are going to be able to provide iron for the world for a long time to come. As a matter of news, and not particularly because it is of interest, but because it is germane to some extent to your interests here, we say that a few years ago iron was first discovered in Minnesota. The conditions have been materially or completely changed in the meantime. As a matter of fact, when the Mesabi Range was first opened up no one thought the commercial ore was of great value, being what they call 60 per cent ore. Then it ran to 55 per cent ore. That is almost the standard now. Even out on the western part of the Mesabi Range they are mining very profitably 35 per cent ore, because the steel company understand the conservation of their natural resources. Because of a washing process, they raise the standard of that ore to 50 or 55 per cent for commercial uses.

The great bodies of ore which have been discovered have been made useful by the conservation of their resources. West of the Mesabi Range we are opening what they call the Cayuna Range, and the ore is in very much deeper bodies, not of so high grade, but all new. The most sanguine promoters, if I might use that term, declare that the finding of ore on the Cayuna Range will vastly eclipse the Mesabi Range; so that we have every reason to believe that within a few years we are going to develop sufficient bodies of ore to take care of all the needs of this country for the next two hundred years, and, as Mr. Cole, the general superintendent of the Oliver Mining Company, said something like a year ago, when I was talking with him about it, "We have just begun to scratch the earth." I do not say that in a spirit of boastfulness, so far as Minnesota is concerned, or so far as the National Government is concerned. It is rather a matter of humiliation to me to know that those great iron resources of the country at one time belonged to the Federal Government and later to the government of the State of Minnesota, and by reason of the lack of interest of the people in the conservation and ownership of their natural resources, they have allowed them to pass into the hands of special interests. They are there, and they belong not to the National Government, not to the State of Minnesota, except in small degree. It is very important the National Government and the state government should conserve that which they do own and see to it that it does not pass into the hands of private owners in the future. But it is a matter of humiliation that it has gone as far as it has and into the hands of private parties.

Let me say in behalf, too, of the private individuals who own it, that owning a private enterprise means the conservation of its natural resources. There is no question of the interest of the steel company in the protection and preservation of their own property, and because it is a private enterprise they will look after the details of their business much better and much closer than state or governmental enterprises are looked after. Because of the things they have done, the Federal Government and the state government, too, can learn a very valuable lesson, and that is, in all material things at least, to conduct their business on the same broad lines of business interest which characterize a successful business man in the conduct of his private affairs. When we have divorced our public business from political considerations—and I was much moved by a remark I think by the President yesterday, who said that this should not be made the vehicle for the enhancement of any political fortunes—then the situation will be more desirable. If we will use as a measure of public good, using for our own benefit and our own advantage the lessons which come to us from successful business men's enterprises, we will do much to conserve our natural resources in that particular direction.

Now, this steel company not only owns mines in Minnesota, but mines in Alabama—and when I speak of Alabama I mean the Birmingham district—and has, by reason of experience, learned to conserve natural resources; and I am quite amused, so far as the iron industry is concerned, to hear people talk about the waste.

In the Mesabi country, as a matter of fact, I want to say it is all open-pit mining, not the underground mining; that is still done somewhat on the Vermillion Range. But in the Mesabi Range, the greatest iron range in the world, it is all done by open-pit mining, just as you would strip off a quarry or a sand pit and then start to dig the open ore; and there is absolutely no waste to it at all. There is no waste in the mining in the Mesabi Range. A great waste existed a few years ago because there was no such thing as a by-product, no such thing as coal tar or gas or cement, etc., until to-day, as was suggested this morning, as in the conducting of a great many other private enterprises, those things have become of vast importance and have much to do with the profit of their enterprises.

I am not going to discuss the matter any further than to say that I do take an optimistic view of the situation.

They say while there are billions of tons of ore, possibly the grade is low. The average grade would probably run 50 per cent in that Mesabi Range. The Krupp Works in Germany do business with iron which averages 29 per cent, and if the Krupp industry in Germany uses the average standard of ore in Germany, and that average is 29 per cent, I think there is no particular alarm to be felt about Minnesota ore. But in the country generally, there is no necessity for alarm at this particular time so far as iron is concerned.

I realize iron is a different proposition from what we meet in coal, for instance, because the iron is not, after all, destroyed. It is like some of the other minerals—always with us in some form or another. Where coal is consumed it is gone forever. It is not entirely so with iron ore. We are not particularly alarmed with that particular feature of it in our country. We are interested, so far as the development of iron interests is concerned, and the conservation of the natural resources, because the conservation thereof, in my judgment, if it means anything, means the private development and private exploitation of the industry much along the line suggested by Mr. Walsh.

We say it is kindred to or interrelated with the matter of transportation, and because of the fact it is so in the Middle West, the matter is very important, because with us it is a problem of distribution rather than a problem of mining or the value of the thing itself. For that reason, because we are the greatest iron mining district in the world, because of the fact that we are interested as a mining district, we are interested in this work of an inland waterway and believe that forestry and the inland waterways are kindred and can not be separated from each other.

I believe the great problem for this conference and the great problem for the country in the future is the development of inland waterways. I believe the greatest investment this nation can make to-day, bonded or otherwise, is to construct a canal from Lake Superior to the Gulf of Mexico. It may cost $500,000,000. Estimates have been made at $400,000 a mile. A thousand miles would cost $400,000,000, practically the capitalization of a private enterprise such as the Milwaukee or Northern Pacific, and much less than the capitalization of some of the larger railway systems.

This would solve the matter of rate regulation in the interior of the country and would make unnecessary future discussions between sections or political parties as to whether federal control or state control is best, because then the matter of competition and the matter of reform or better system of transportation would solve that matter of itself, and because then, too, we would have a great route of transportation which belonged not to private enterprises, but which would always be the heritage of the people of this country not only to-day but in the future, and such a canal as I have spoken of, with lateral and spur canals, possibly, would have much to do with the conservation, in my judgment, of the fuel. I believe it would pay for itself every fifty years in the matter of the saving of fuel alone, and would pay for itself every ten or twenty years in the reduced cost of transportation to the people.

We are interested in these things and we are interested in water particularly.

Minnesota is practically the watershed of the continent. Some of you people who are further south must remember that we start the Mississippi River down your way. We have our streams and our forestry and our mines and all those things up in Minnesota, and we are interested in the public conservation of the resources of this country—forests, water, mines, and so forth.

My own opinion is that the proper conservation consists in the proper exploitation and proper development rather than to discontinue the use of it, as, for instance, in Sweden, where I believe the amount of iron ore is limited to 5,000,000 tons per year. We want all those things to use as we need them, but we must properly exploit them and properly develop them. If the work is to be done, it must be done scientifically. It has always been my opinion that this problem was not a politician's problem at all, but that it was after all an engineer's problem. I realized this morning, as I looked at this conference and as I have watched it from the time I came into this room, that the politician is going to eliminate himself from this conservation work, and that the plodder, the man of whom the President spoke yesterday, using him as a type of man, who sits at his typewriter desk and works overtime without any pay or hope of ever getting any, is the man who will have to take it up and carry it on.

I remember at the conference last year at the White House all the governors of the States were there who could be present. Some of them came in to look over the premises to see whether it was really, after all, a desirable place to live at some time in the future. Having satisfied their curiosity, a great many of them are not here now.

A VOICE. You are still here!

Governor JOHNSON. And always will be on such an occasion.

Many of their conferees, having met in the White House, were satisfied with one experience, and then the politician having satisfied the public as to himself, and having satisfied himself as to the public, so far as he was concerned, however, left the work to go to someone else, and there is not that manifestation of interest which was displayed a little while ago, but it is going to grow just the same. This movement, if I understand it, is bigger than the Government, it is bigger than the conferees, it is bigger than the conference, it is bigger than the nation itself, and I am of the opinion we will all live to see the day when history will write into its pages the greatest achievement in the record of this nation's present chief, who made possible the conference last May, and who made possible this conference, because out of it and because of the activity of the scientific men of this country will come great good for the future of our country.

As I said at the outset, I am not a pessimist, neither am I unduly an optimist. I want to say to you, however, that if you will give us, by canal or otherwise, as good a mode of transportation as Germany has, for instance, we will guarantee to furnish you all the iron that this country wants for at least two hundred years, and you can husband the resources of Georgia and Alabama and every other section of the country.

GOVERNOR HOKE SMITH, OF GEORGIA.

The CHAIRMAN. We will now have the pleasure of hearing Governor Hoke Smith, of Georgia, whom I now present to you.

Governor SMITH, of Georgia. Mr. Chairman, ladies, and gentlemen, I was not one of those who had the fortune of looking in upon the White House the first and last time Governor Johnson was there. Indeed, this is the first time I have had the opportunity of being with you.

I have felt a deep interest in the objects of this gathering and agree with Governor Johnson that among the many good things our President has suggested, perhaps no one will last longer or produce greater benefit to the entire country than the organization which is here to-day.

We heard yesterday from Judge Taft that he had a splendid speech but would not deliver it for fear someone would recognize its authorship. Unfortunately for me, Mr. Pinchot did not know I was coming, so that I have not even the prepared speech his fertile pen might have furnished, but I wish to express my very great sympathy for the objects of this organization. Great benefit must come from it.

I do not understand your work will be limited merely to the preservation of what we have. Certainly such a course should not be followed to the extent of retarding the use of the resources of our country, and we are not ready in Georgia and Alabama to stop mining just to let Minnesota, which State can not compete with our efforts, have a chance. I believe that as speedily as possible the resources of our country should be brought into active use, provided that use is made without waste.

I believe that we should study our resources, and that one of the consequences of this gathering, and this general movement taking place throughout the country aided by local conservation organization in each State, will be the more complete investigation and comprehension of the material possibilities found in each State, thereby giving a more complete knowledge throughout our entire country of what there is in each one of the States.

This movement has aroused interest in Georgia and adjoining States. We hope to bring into active cooperation quite a large number of men, not only experts employed by the State in connection with such work, but public-spirited business men, men of property who desire to know more fully than they now know just what are the possibilities within the soil and within the mountains of our part of the Union, as they learn also what may be found that is yet undiscovered in other parts of the Union.

This knowledge should stimulate the best possible use of our mineral wealth and material resources. Substitutes will be found for things now wasted by their use. Less expensive and less valuable material will be substituted in use for commodities of larger value. The resources of our nation will be conserved by that knowledge and intelligent use which will make them tell for the most when used.

I do not desire to speak of the special resources of my section. It is not necessary to tell you that my immediate section fixes the price of pig iron the world over. I will tell that to Governor Johnson. We have vast bodies of iron still undeveloped in the State of Georgia. They are not being rapidly developed because in Alabama all the ingredients necessary for the assembling of those commodities required to make steel can be brought together cheaper than in our State. The ore beds of Georgia, therefore, will wait to a large extent for future use. We are making great progress in producing a substitute for steel. We are utilizing slate and lime located side by side to make a cement of the highest quality. Plant after plant of this character is being erected producing vast quantities of Portland cement, which must in structural matters largely relieve the pressure upon our iron-ore beds.

Assisted by the study of our resources, we will find substitutes for many things now used less expensive than those now used. We will learn how to use in the best possible way what we have. Knowing what we have all over the land, conservation will come, not from a lessening of activity, but from a quickening of those forces in the best possible way, with the best results, due to the knowledge of what we have, and how to use what we have. After all, it is not the rich field, but the minds of the people of the State that make the wealth of the nation.

Along with the progress which will come from study of our resources, and an effort to conserve them, must come the better preparation of the boys and girls of our country to handle in artistic style and with the master's hand whatever either may be called upon to do. From the simple handling of the hoe in the field up to the highest mechanical skill it behooves us, as a part of the progress for which we all long, as a part of the power commercially of our nation, which we now have and which we would hand down with growing strength from generation to generation, to see that every child is taught to use his hand with a perfect skill, and we must neither yield in resources nor in capacity of our skilled artists and mechanics to Germany or to any other country in the world.

So it is, Mr. Chairman and gentlemen, we come to you from our part of the country, rich, we believe, in resources of the most varied character, bent upon studying them, bent upon seeing they are utilized in the most profitable way, not alone for the profit of the one who owns them, not alone for advancement of the commercial and financial strength of the locality where they are found, but with the common purpose that our country, our great nation, to-day, to-morrow, and hundreds of years hence, shall fill that place which our patriotism and our love assign to it—absolutely the first among the nations of the world.

RECESS.

Governor **Blanchard**. In acordance with the prearranged program for the guidance of this conference, I now move that the conference take a recess until half-past 2 o'clock this afternoon, after which these interesting discussions by the governors shall continue.

(Motion put and carried.)

(Thereupon, at 1 o'clock p. m., the conference took a recess until half-past 2 o'clock p. m.)

WEDNESDAY AFTERNOON, DECEMBER 9.

The chairman, Mr. Pinchot, called the conference to order at 2.30 o'clock p. m.

The **Chairman**. Before we take up the subject of lands, which is set on the program for consideration this afternoon, I have to announce the appointment of the committee on resolutions, according to instructions given me this morning.

The committee on resolutions will consist of governors, past, present, and future; the future governors being limited to those concerning whom we are sure there is no doubt of their being governors, and not those who may likely be governors.

The next order of business is a statement by Senator Nelson as to the subject of lands. I take great pleasure in introducing Senator Nelson.

SENATOR KNUTE NELSON, CHAIRMAN OF THE SECTION OF LANDS, NATIONAL CONSERVATION COMMISSION.

Senator **Nelson**. Mr. Chairman, ladies and gentlemen, you who were here this morning heard the joint report of the conservation commission and the part of it relating to the matter of our public lands. This question of conserving our lands in this country resolves itself into really two different heads. One relates to the conservation of the lands that are now in private ownership, conserving them against soil erosion, and also against improper use or unwise, improper agricultural methods. That part of the problem is very well covered in the special reports that will accompany this general report. This problem relates more to the care-taking by the States than the Federal Government, for the underlying principle in reference to land matters is that where land has passed out of the hands of the Federal Government, the jurisdiction of it is under the laws and regulations of the respective States. So that whatever is done in the way of conserving lands that have passed into private ownership, the problem relating thereto must be in the main worked out under state legislation and through private efforts.

Indirectly the Government can help out in this matter, at least so far as the matter of soil erosion is concerned and so far as the matter of water is concerned, by the regulation of streams, but in respect to wasteful methods of farming and in respect to these other matters that go to the deterioration and diminution of the value of the land for agricultural purposes in the main, that is a problem either for the States or for the individual citizens.

The question to which I propose to briefly call your attention is the conservation of the public lands that are still in the ownership of the Federal Government, and before I state anything on that subject I want to call your attention to what we still own.

According to the latest statistics on this subject, we had upon the first day of July last 386,873,787 acres of public land that were unappropriated and in the Government's name and not in a state of reservation. We had in addition to that 6,400,000 acres of land in Indian reservations and we had 167,976,000 acres in forest reserves. This relates to the lands that we have within the continental boundaries of the United States and does not include the Territory or district of Alaska.

The great object or purpose which we ought to have in view is to conserve these lands for the benefit of the American people. One of our great safety valves in the past, when we have been in the midst of periods of industrial stagnation and paralysis, when we have found a large army of idle men in our industrial centers and our large cities, has been the fact that many of those people who failed to get work in those industrial centers in the large cities could wend their way to the frontier and take up public land and make little homes of their own. That has been to a large extent our safety valve in the past. The question is to preserve that for future use.

I have figured out that all of the unappropriated public lands which we now have, which are not in forest or Indian reservations, fit for agricultural purposes, would amount to 2,292,000 homesteads of 160 acres each. According to the statistics, we had at the last census 6,000,000 farms of 146 acres each. If all this public land that is still in a state of reservation could be conserved and utilized for agricultural purposes, it would furnish homes to 2,292,000 homesteaders.

One of the great problems, perhaps the greatest problem, we have on hand to-day is the utilization of these lands. Fortunately, we have such a large body of lands in forest reservations. I think that is one of the most fortunate things that has occurred in recent years in respect to our public lands.

Some years ago we tried to repeal the stone and timber law under which so many of our valuable timber lands had been appropriated at a cost of not more than $2.50 per acre. While such a bill was passed in one House of Congress, it failed to pass in the other body, and as a consequence, if it had not been for the fact that so many of our lands were segregated and put into forest reservations, we would to-day have been in a far more deplorable and precarious condition in respect to our timber lands than we really are.

We are fortunate in having this large body of lands in forest reservations. These lands are in charge of our worthy chairman, Mr. Pinchot, who, as you all know, takes a pride in carrying on this great work of forest conservation and forest preservation. When we come to think of the history of how our public lands have been disposed of in the past, it is perfectly appalling. We began at the outset by selling, aside from filling certain grants to officers and men of the Revolutionary army and some of our other wars, our lands at public sale or auction, auctioning them off in large bodies to the highest bidder, and those lands that were not bid in at public sale were offered afterwards at private sale at a minimum of $1.25 per acre, and from that usage we got the terms " offered " and " unoffered " lands. Offered lands were those which had been offered at public sale, when if not so sold they could be purchased at private sale at $1.25 an acre. Land that had been offered at public sale and not sold was open to private sale, or " private entry," at $1.25 per acre.

After we had continued under this policy of selling lands first at public sale and then at private sale, the United States took another step, which was to adopt the preemption law. That, for the time being, was of great value and great assistance to pioneers, because it enabled them to get a brief period in which to raise the money to pay for their land. Originally they could go and occupy surveyed and offered land, and file a declaratory statement, in the district land office, and have a year in which to pay for the land. Afterwards that was so modified that they could occupy surveyed and offered lands and have two and one-half years after settlement to pay for it, and on surveyed lands the same period after the plats of the survey were returned to the local land office.

In addition to these methods of disposal, we got (1862) the homestead law, which, in its main provisions, has been one of the great home builders of the country; I mean one of the great instrumentalities through which our western country has been opened, settled, and developed, and, barring some defects, it is one of the best land laws that any country has ever adopted or worked under. The defect of that law was in the " commutation " provision. Under the law as first passed a settler could " enter " his homestead, and after living on it six months could " commute " by making final proof and paying the Government the price. In many cases, however, the man who made the original entry and " commuted " did not become the permanent occupant of the land; he would dispose of it at the first chance, and thus it would pass into the hands of speculators. " Commutation " was subsequently modified so as to permit " commutation " in fourteen months. At first the Land Office interpreted that law so as to allow commutation eight months after the expiration of the first six months in which they were required to settle on the land. Afterwards the Land Office abandoned that construction, and now and for some time past it requires fourteen months actual and continuous residence before commutation can be made.

But even under that modification the records will show that a large number of homesteads are commuted, and as soon as commuted and proved up and paid for they pass into the hands of speculators and middlemen who hold them simply for a rise and not for the purpose of themselves utilizing them for agricultural purposes.

In addition to these land laws which I have briefly mentioned other laws have been passed, not so beneficent. They were no doubt designed for a beneficent purpose, but in practice they worked out unsatisfactorily. We had years ago what they called the " timber-culture law." The object of that was to promote the growth of timber on the prairies of the country, but experience showed that law was almost a failure in that respect. In the Western States, where they made these timber claims, a few trees were raised on some claims, but on many timber claims you can scarcely find a tree growing. That law was repealed some years ago. After the timber-culture act came the stone and timber act, which was no doubt passed for a beneficent purpose, for the purpose of permitting the entry of stone and timber lands that were wholly unsuited for agricultural purposes, by men who actually wanted the land for their own use. But in recent years that law has been made the vehicle under which the big lumber men have been enabled to secure large bodies of our best timber lands, to such an extent that a monopoly is threatened.

Another law was the law allowing relinquishment of lands in forests and other reservations and the selection of lieu lands in other parts of the country. Some years ago Congress passed an act creating the Mount Rainier Reservation. It was largely within the limits of the Northern Pacific Railway grant, and the land was mostly worthless. A great deal of that land was of very inferior character, with little or no timber on it. The railway company was allowed, under that law, to relinquish that land and select other lands in lieu thereof, and under that law and this right the company transferred to big lumber syndicates, who selected some of the best timber lands in the Western States in lieu of the worthless Mount Rainier lands relinquished.

The stone and timber act provided in terms that the land should be sold at a minimum price of not less than $2.50 per acre. Until recently, the Land Department has been construing that to mean the maximum price, and the lumbermen or other intermediaries who secured these lands have secured the most valuable of fir and pine land for $2.50 per acre. The Land Department has recently put a new construction on the law, holding that $2.50 per acre is merely the minimum limit, and that the Government can charge a higher price in proportion to the value of the land. If that rule is enforced, it will be a great protection for us, but in order to enforce that rule the Government, through its officials, will have to investigate and examine these lands, classify them, and determine as far as they can the quantity of timber, in order to fix the price for which these lands should be sold.

In my opinion, and I speak only for myself, all our timber lands not now included in forest reservations should be retained by the Government and never sold, but the Government should retain possession of them, conserve them, and merely sell the mature timber from time to time as the necessity arises. That is the only possible way in which we can conserve our timber supply.

Now, with reference to the agricultural lands—I mean lands not covered with timber and suitable for agricultural purposes. These lands are chiefly in the western portion of our country, west of the Mississippi, in the arid or semiarid belt. Some of them can be farmed by dry farming, some by irrigation, and some of them can be farmed by careful and prudent farming by the ordinary method.

I have grown up in two frontier States, first in Wisconsin and then Minnesota, and I have noticed one thing, and that is the arid belt and frost belt seem to retire in the face of settlement. I can remember twenty-five years ago, when the earliest settlers went to the neighborhood of Minot, on the Great Northern Railroad in North Dakota. The early settlers who went there in the first instance were literally starved out by the drought. They left and moved back into the timber in Minnesota. Within the last ten years settlers have gone in there around Minot and have raised crops successfully for the last eight or ten years, and that country now is regarded as good for agricultural purposes as any part of the great State of North

Dakota. The same thing is true in the matter of frost. I can remember some eighteen or twenty years ago, when our wheat in northern Minnesota in that territory north of a line through Crookston and Grand Forks was bitten by the frost before the crop was mature. We have not had anything of that kind in recent years. Look at the conditions immediately north of us in Canada. I visited that country last summer, and to me it appears that both the frost line and the arid lines are driven westward and northward in the face of settlement.

I believe a great deal of the land that we considered useless at one time—useless at all events without irrigation—can be farmed successfully by prudent and careful methods.

I noticed as I was passing through that country that those crops of the farmer raised on summer-fallowed land looked much better than other crops. I was told by people in North Dakota that crops raised on summer-fallowed land were considered pretty sure crops, while as to the other lands they were not at all sure, on account of drought and hot wind in the summer.

My idea is that for the welfare of our people, and in order to furnish homes for our future population, we ought to save all this great region of country that has not yet been taken up under our land laws for homestead settlers only. It should all be saved for homesteads for present and future generations.

There are plans pending in Congress to make these homesteads larger. There have been plans and Congress succeeded in passing a law some years ago applying to certain localities in Nebraska, fixing homesteads at 640 acres. I believe bills are pending in Congress now for 320-acre homesteads. It may be that in one sense a 320 or 640 acre homestead intrinsically is not too much, but we must bear in mind the amount of land we still possess and the number of people who will want land in the future, and I think the wisest and safest policy, if we consider our future interests, is to limit our homesteads in all cases to 160 acres.

There is another problem. Of course, where the Government still retains ownership and control of timber lands, the problem can be easily handled by the Federal Government, but when you come to the matter of protecting our timber lands from forest fires and other damage, lands that are in private ownership and within the several States, you will find it to be a problem that appertains to the States and belongs to the police powers of the States. Our forest fires in Minnesota last fall, when one of the prosperous towns up on what we call the iron range was totally destroyed, as well as other fires we have had there, all demonstrate that one of the causes that feeds these forest fires and makes them so dangerous is refuse that is left by the lumbermen when they do their logging. I think that it is entirely within the police power of the respective States, for the protection of the lives and the property of their people, to pass laws requiring lumbermen, when they do their logging, to burn up and destroy the refuse and waste matter, just as is now required by the forestry department of the United States. But we must look to the States for that relief, and all we can do in this convention, my friends, is to give them good fatherly advice and good sensible suggestions.

I think that the two great problems or the two important questions, so far as our public lands are concerned, are, first of all, to reserve all our agricultural land for homes. In the next place, we should retain our timber lands absolutely in the Government, and sell nothing but the matured timber. In the next place—and I agree with that part of the report—it is well to segregate these different rights. The timber lands should not be sold, agricultural lands should only be sold so far as the surface goes, and the mineral rights should be held separately and disposed of separately. I am free to confess, however, in respect to that question I have some doubt. I can readily see how, in the matter of coal lands—for instance, the lignite coal lands in Dakota—it is quite practicable to give the surface right to one man and the right to the bed of coal beneath to another man, and how the two men could work in harmony and unity; but when it comes to a matter of mineral claims, such as lode claims and placer claims, then there is some question about working out the problem. As a rule, most of the lode claims are on the mountain tops and mountain sides, and very little of the land covered by those claims is fit for agricultural purposes. The same is true in reference to placer gold mines. They are generally found in the ravines and gulches and beds of rivers, land that as a rule is not of much value for agricultural purposes. So it seems to me there is necessarily no conflict, and in making up this general report I felt perfectly safe in agreeing to the general proposition. I think the commission has made a wise and judicious recommendation to the people of the United States. Bear in mind, gentlemen, we can only work out this problem completely and thoroughly by the active work of the Federal Government and by the active cooperation of the several States, as well as the individuals.

When it comes to this matter of policing our forests that are in private ownership, the great work in reference to that must be left to the States. When it comes to protecting our own forests and controlling them, the Federal Government has absolute power in the matter. When it comes to the regulation of our water supply, the Federal Government has control of all these streams so far as purposes of navigation may be concerned. Governor Chamberlin yesterday, in his speech over at the Belasco Theater, announced, in my opinion, the correct rule.

The correct rule was laid down by the Supreme Court of the United States in the Rio Grande case, and that is that even that portion of a stream which is above the head of navigation, if it be the headwaters of a navigable stream, is nevertheless, on account of its effect upon the navigability of that portion of the stream lower down, absolutely under the control of the Federal Government.

Now, gentlemen, I have in the rough stated to you how the problem appears to me. I can only say to you that as a representative of our Federal Government, here in Congress, I shall aim to the best of my ability to work along the lines suggested by this report, so far as the interests of the Federal Government are concerned; but you governors and you representatives of the several States have a greater problem even than we have, and we must rely upon you more than upon anyone else to cooperate with us in this very important matter.

I trust that while we may not all agree as to the details, yet in respect to the great general problem in hand we shall all work together as good patriotic American citizens, not only looking to our own immediate welfare, but to the welfare of the generations to come, in order that our grand country may continue to grow and prosper in the future as it has in the past.

GOVERNOR EDMOND F. NOEL, OF MISSISSIPPI.

The CHAIRMAN. This subject naturally falls into two parts, the public-land question and the agricultural question. Governor Noel, of Mississippi, has signified his willingness, on my request, to speak on the agricultural side of the question. I take pleasure in presenting to you Governor Noel, of Mississippi.

Governor NOEL. As with Governor Smith this morning, this call comes unexpectedly, and upon a topic to which I have given no recent study. In our section, especially in Mississippi, nearly all public lands, unfortunately, have passed into private ownership, leaving small basis for forest reservations. Originally our fertile soil, mild climate, and large and well-distributed rainfall made almost the whole country woodland. The forests of Mississippi contain about 120 different species of trees, consisting of numerous varieties, there being 15 of oak. The large pine forests of south Mississippi, and of hard wood in the delta, are being rapidly cleared, usually by methods unnecessarily wasteful. The chief consideration with many seems the largest delivery to mills at the smallest outlay, wholly regardless of the effect on other industries or on posterity.

Mississippi is preeminently agricultural, and with over 58 per cent of its population negroes it has a much larger proportion of its wealth and population engaged in or dependent on farming than any other State. In its early days, when the soil was fresh and fertile and much of the forests were undisturbed, almost any method of cultivation produced bountiful harvests. When the soil became thin from unchecked erosion and continuous replanting of the same crops without fertilization, it was often abandoned to gullies, and other and fresh fields obtained by destruction of their valuable timber. Warned by lessening returns for the fruits of their labor, a general effort is now being made not only to check this downward trend, but to reverse its course, and through improved cultural methods and judicious selection of plants, animals, diversification of crops, and fertilization, to fully restore the productive power [illegible] land and labor. This movement has been given great impetus by the well-considered and admirably executed measures for the conservation of our natural resources, initiated by the President and ably seconded by various worthy government officials, especially by the Secretary of Agriculture and by our chairman.

Food and clothing, the prime necessaries of life, come originally from farms. Therefore every man, woman, and child, at all times and everywhere, are directly concerned in advanced and successful agriculture. In many ways and in all parts of the Union the Department of Agriculture, through its varied activities, has become more and more helpful. By cooperation with States and their subdivisions, surveys, topographical, soil, and surface and underground water, are being made and mapped, instructing the people in the quality and capacity of their natural resources and of the most approved methods of utilization. Intelligent and successful farming and stock raising are manifested by putting land and labor to the most permanently profitable use, profitable in its broadest sense, as affecting both present and future generations. The Agricultural Department of our Government is ably supplemented by our agricultural schools and colleges and their experimental stations, where the best selections of seed, animals, and cultural methods are accurately and scientifically tested with reference to varied climatic and soil conditions. This information is disseminated in an easily understood form. Steady and rapid advances are being made in the treatment of injuries resulting to plant and animal life from all causes, some being but recently discovered.

In the South the Federal Government is extending effective and greatly appreciated help in our fight for our cattle as against the fever tick, which costs us tens of millions of dollars annually in losses to cattle; and also in our fight against our small but dangerous enemy, the boll weevil, which crossed the Mexican border about sixteen years ago, marching steadily northward and eastward through the cotton belt, never wholly abandoning territory once invaded, and carrying immense damage, if not temporary ruin, to all who do not avail themselves of the new cultural methods tested and taught by the Department of Agriculture and its cooperating agencies. Though I come from a State probably the most united as against the dominant political party, we gratefully acknowledge and cordially welcome the very effective assistance extended to us by the National Government.

About one-third in value, and one-sixth in area, of the lands of Mississippi, and considerable parts of Louisiana and Arkansas, are protected from ravages from floods by levees, which levees also aid river navigation, and are sufficient for these purposes except when extreme high water brings death and destruction to life and property. Those inhabitants and all others of our State and of many other States are vitally interested in whatever affects, especially in the Mississippi basin, the distribution and disposition of rainfall, which are materially modified by the removal or the replanting of forests. The muddier the water the more difficult it is to control and the greater is its power of erosion and of making sand bars. Careless methods of cultivation not only rob the land, through erosion, of more fertilizing properties than is consumed by crops, but also aggravate the evils and reduce the benefits of water courses. In speaking of his State, Minnesota, Governor Johnson announced that it supplied part of the waters that passed through the lower Mississippi. For water of proper quality, free from unneeded sediment, and properly distributed throughout the year, the people of the lower Mississippi Valley are exceedingly grateful, but not so for muddy floods, delivered in such volume as to defy human control. The occupants of the lower Mississippi Valley are the greatest sufferers from the sins of deforestation and of soil erosion of the whole Mississippi basin and should be fully protected from overflows of the Mississippi by the strong arm of our Federal Government, which has the entire control of the waters and the navigation of the Mississippi River.

Kind Providence has been exceedingly gracious in its bestowal of the blessings of a fertile soil, a genial climate, and well-distributed rainfall to Mississippi and other Southern States, bringing prosperity to all who make good use of their opportunity.

The whole Mexican Gulf coast, outside of lower Florida, which is really tropical, can successfully grow almost all kinds of tropical fruits. Mississippi can profitably produce nearly every kind of crop, vegetable or fruit. For farming and pasturage our lands are almost ideal. Our summers are long, with nights generally pleasant and days not excessively warm. Our winters are short and mild. When not already fertile, our lands can generally be made fertile at a moderate expenditure of time and money. Cattle can thrive throughout the year with little or no shelter, and need be fed only for a few winter months, and in some localities not at all, cane and grass there affording perennial subsistence.

My mission here is not one of speechmaking, but of listening and learning. I have gathered from some of the best posted authorities much valuable data pertaining to the value and location of our natural resources and of the best means of obtaining its benefits without unnecessary exhaustion. The most valuable service that I can render Mississippi is, directly and through various agencies, to bring its citizenship into a full and living realization of the material data affecting the extent and conservation of our natural resources, which have been so wisely and diligently collected and so admirably presented to this conference. I thank our President, the chairman of this conference, and all of those who have rendered this efficient public service, and sincerely wish them godspeed in their useful and patriotic labors.

GOVERNOR MARTIN F. ANSEL, OF SOUTH CAROLINA.

The CHAIRMAN. During the last address Governor Ansel, of South Carolina, has come into the room, and I am sure we shall be glad to hear from him. I take pleasure in presenting to you Governor Ansel, of South Carolina.

Governor ANSEL. Mr. Chairman, ladies, and gentlemen, I do not know whether my friend, Governor Johnson, is in the house this afternon or not, but it was my pleasure to be with him at the first conservation meeting that was held at the White House in May, and I want to tell him that I am one of the governors here to-day and that I am one of the governors who expect to attend these meetings in the future. It is a great pleasure for me to be at these meetings, not only a great pleasure and privilege, but it has been a great educator so far as I am concerned.

The conservation of our natural resources is something that has been in my mind for some little time, and more particularly since the first meeting was called when so much information was given to each of us of the great possibilities, the great wealth of this great country of ours. I am not a pessimist, my friends. I am an optimist, if anything, and I believe that we have the greatest country in the world: in fact, I know it. I know that our natural resources are equal to those of any of the nations of the world, and even the small State of South Carolina has tin within her borders, and it has been recently mined to a profitable degree. We have also large deposits of monazite, and I believe monazite is only found in the States of North Carolina and South Carolina.

This discussion this afternoon is on the subject of lands, if I am not mistaken. I am sorry I was not here at the beginning of this afternoon's session. The trouble with me is I can not divide myself into two or three people at one and the same time. I wanted to attend the Rivers and Harbors Congress, which is in session on the tenth floor of this building. This morning I was before the Agriculture

Committee of Congress talking about the Appalachian Forest Reserve, one of those things in which we are very much interested in our country; and I wanted to be here at the same time. My heart is in this work.

We had a great flood in August of this year and the loss of land, of ground, of soil was something enormous as the result of that one flood. While crops were devastated, while the corn was carried off, yet that was only a part and a small part of the great injury that was done to our lands by carrying them into the sea by the flood such as we had in August last. That, of course, gets back to the question of the forests and of the waters, and I have not time to discuss those questions this afternoon. I want to say that we feel down in our country a great interest in this question of the preservation and conservation of our natural resources.

Our lands, our waters, our forests, our minerals are things in which each and every State of the Union is interested, in order that we may send down to posterity that which we received from the good Lord when we came here.

I never until recent years fully appreciated that little couplet I learned as a small boy:

Woodman, spare that tree,
Touch not a single bough.

Little did I think then that the tree would become so important; so important as it is to-day in the question of forests and deforestation. Little did I think then that so much interest would be manifested in our forests, so important to our landed interests, that the tree should be protected in order that the floods would not carry away the land; that the forests being denuded would permit the silt to go down the river as it does in these large floods.

I am not here on this program to make any speech to you upon this subject, but I am here to tell you something of the interest we feel in our portion of the country in this great question that is now being discussed from one end of this country to the other. If this great conference does nothing else, my friends, than to make us think and make us act upon the knowledge that we have, these great reserves that we have an interest in, the preservation of these resources for our posterity, our children, and our grandchildren, it will have accomplished a great deal.

I for one wish to thank my friend, the chairman of this meeting, for the great interest he has manifested and shown in the great work of preserving our natural resources. I have had many communications with him upon the subject and I know that he has in his heart the interest not only of one State and another State, but all the States of this Union, in the preservation of these things which make the material wealth of our country and which are to be handed down to posterity. We live not only for ourselves, but for our children. We should preserve to them those things which are necessary in order that they may receive from us what we received from our forefathers.

I wish, therefore, this afternoon just to bid you godspeed in the great work that has been started here and to express the hope that it may be carried forward and result in the preservation and conservation of these great resources of ours in order that the country may go forward as it has been going, continuing to hold her place as the first nation of the world.

GOVERNOR N. B. BROWARD, OF FLORIDA.

The CHAIRMAN. I thought I saw Governor Broward, of Florida, come in while Governor Ansel was speaking. I know we shall be very glad to hear from him, and I now take pleasure in presenting to you Governor Broward, of Florida.

Governor BROWARD. Mr. Chairman, ladies, and fellow-citizens of the United States, I will not undertake to make a speech this afternoon, as I have been so busy since coming to Washington, attending first one conference and then another, that I fear my remarks might be so scattering on this subject, without some study, that I would fail to hit anybody or anything.

I heard a story told once that is apropos of my condition at this time. An old gentleman frequently went out squirrel hunting with his son. The old gentleman was slightly palsied, and it was his province to shake the bush and frighten the squirrel around on the other side of the limb, and the province of the boy to do the shooting. On one occasion the old gentleman had scared the squirrel around on the other side of the limb several times, and the boy had several clear shots at the squirrel but missed him every time. The old man, becoming vexed, and ammunition being scarce and costly, said: "Come here and shake the bush; let me shoot. Let me try it." The boy went over and shook the bush, and the squirrel went around on the other side of the limb, and the old man held the gun up and shook all over, and finally the gun went off and down came the squirrel. The old man said: "That is the way to shoot. That is the way to shoot." The boy said: "Well, no wonder you hit him; you aimed all over the tree."

On this occasion I would have to aim all over the tree and all over the continent, and I would rather reserve the right, if my friend will permit me, to wait until to-morrow or some other time that suits him, when I can better entertain you on this subject. I have a scattering knowledge of it or conception of it, and realize to some extent its great importance, and as I look into the faces of those who have studied it closely, and especially that of the Senator from Nevada, who, next to Mr. Pinchot, has done the greatest work along this line, I feel that the generations yet unborn will appreciate to some extent at least the great things that will be in store for them as the result of the persistent efforts of those two gentlemen who did not live entirely for themselves.

I thank you.

SUGGESTION BY SENATOR FRANCIS G. NEWLANDS, OF NEVADA.

Senator NEWLANDS. May I make a suggestion, Mr. Chairman? The last Conservation Congress emphasized the importance of cooperation between the National Government and the States upon the questions which we have under consideration. The report recently presented emphasizes the importance of cooperation. A year has passed by since the last conference was held. There has been some opportunity for state action upon this subject. I think it would be quite instructive to this conference to ascertain what action has been taken in the various States and also to discuss some method of uniform action by the States upon this subject. I have recently received a letter from the governor of my own State, Nevada, in which he expresses an earnest desire to cooperate with the National Conservation Commission in this work. He requests information and suggestions upon the subject. Yesterday I was handed a report by the Conservation Commission of Oregon. I have had no opportunity yet to look it over. That report indicated that Oregon has already taken action. This was quite a voluminous report, some 60 or 70 pages.

Let me here suggest that state action can be taken in two ways—one by the passage of a statute by the legislature, the other by executive action. Of course, it is highly important that action should be taken by the legislature of the State, because then some efficient method of action is always indicated. But where that has not been secured, or where it is difficult to secure, it is entirely within the province of the governor of any State, under the power which he has of recommendation to the legislature with regard to legislation. to call to his aid any body of citizens, and he can give such body such name as he may choose, and I would suggest that where States through their legislatures have not taken action, the governors of the various States can appoint, just as the President of the United States appointed, a conservation committee of the State, with a view to preparing a report and making recommendations to him. It will be a very fruitful method of agitating the question, of forming public opinion upon the matter, and the result will doubtless be, in every State, that the merely recommendatory commission appointed by the governor, without constitutional action and without legislative action, will ripen into legislative action which will cover the field of administration as well as the field of recommendation. I would suggest that as the governors and Representatives of the various States are called upon they say something regarding the previous action of each State upon this subject, the action which has already taken place, and the action which may be contemplated.

The CHAIRMAN. I am sure Senator Newlands's suggestion is good. I may say at the beginning that 28 of the States have appointed conservation commissions, and some 30 of the great national organizations are represented here. I, too, have before me the report of the Oregon commission. Other commissions have already prepared reports, and I am certain that the conference will be very glad indeed to hear, from either the governors or the chairmen or representatives of the state commissions, what has been done.

Senator SMOOT. Have we passed from the subject of public lands? Have we said all that is going to be said upon that subject?

The CHAIRMAN. No; the subject of public lands is still before us for discussion.

Governor ANSEL, of South Carolina: Responding to the suggestion of my friend, so far as South Carolina is concerned, we have no statutory provision upon that subject, but since the meeting of the governors last May I have appointed a conservation committee, consisting of our commissioner of agriculture, state geologist, and two other citizens, and they are to report to me, giving me the information they have in order that I may take such action in my message to the legislature as may be thought best, and I believe they have also given Mr. Pinchot data with reference to the matters upon which he desired information.

The CHAIRMAN. I would suggest in this connection that the National Conservation Commission has had a great deal of encouragement and assistance from the governors and their commissions.

HON. W. P. LAY, OF THE ALABAMA STATE CONSERVATION COMMISSION.

Mr. LAY. Mr. Chairman, as to the reports from the States and the conservation commissions appointed for the States, I have the honor of being chairman of the commission appointed for Alabama, and therefore beg to say: We prepared a report and turned it in to your honorable secretary, which report I believe you have before you. The report contains probably 50 or 75 pages and takes up the various subjects, I think, fairly well—in line with the inquiry.

We covered the ground the best we could considering the short time in which we had to work, and considering also that we had no funds at our command to aid us in the work. We found the duties very arduous, yet very interesting, and as we examined into the various subjects we could realize more and more the importance of the work.

We took up each subject in form as the inquiries were made, as the report will show. First, the land laws; second, agriculture; third, waterways; fourth, forestry, and fifth, minerals, and made as complete an inventory of each as our limited time would permit, together with recommendations as to how, in our opinion, some of these could be most economically handled—that the best and most lasting results might be obtained therefrom.

In looking into the subject we found some very interesting questions and the field large, and one that offers very great opportunity for study and research.

One of the conclusions at which I arrived was, that of all our natural resources I do not know of any that promises more results than is promised by the proper conservation, improvement, and development of our waterways. In fact, it occurs to me that the most potent factor in conserving our resources is to first conserve, improve, develop, and utilize our streams. When this is done, in my opinion, the greatest achievement in our efforts for conservation has been accomplished.

To fully appreciate why this is so, we must consider:

First. The use and benefits to which these streams can be applied.

Second. Their possibilities to contribute such benefits when they are improved so as to utilize their natural flow, and when they are improved so as to utilize their practical conserved flow.

Third. The economy and saving which they are capable of accomplishing when so improved.

CHIEF VALUE OF STREAMS.

The chief values of our streams are for navigation and for development of power; therefore, if the plans for their improvement are properly designed with due consideration for conserving both these valuable agencies of human affairs in the most minute detail, their joint development and improvement can be most economically accomplished, with the promise also of the most economic results from their joint operation.

DUAL SYSTEM.

With this end in view, it will be seen by examining our report that we recommend most heartily, for the improvement of our waterways, a dual system of navigation and water-power development, where water power is possible, together with a system of impounding or storing the flood waters of the streams in aid of such navigation and power development and the amelioration of the floods. And we recommended also, very heartily, that the Government of the United States in its improvement of our streams for navigation act in conjunction with private capital in the development of the water powers, where such water powers exist, upon such equitable terms as may be right and just, to both the Government of the United States in its efforts to improve navigation and to the riparian owners of the water-power rights.

WATER TRANSPORTATION.

The benefits of water transportation are too well known to need comment from me, hence I shall not dwell on that part of the subject.

VALUE OF POWER.

To be brief in treating on the value of power in its relations to manufacture and commerce, I shall deal principally in statistics, as compiled by Mr. W. J. Clark for the Niagara Falls Power Company.

The total value of manufactured articles produced in the United States during the year 1900 was approximately $13,000,000,000. Five million three hundred thousand wage-earners contributed their labor to produce these articles, and 11,300,000 horsepower was used for manufacturing purposes. Thus, for every wage-earner 2.13 horsepower was used to aid him in producing $2,452 worth of goods during the year. No other country employed power to an extent at all comparable with this, and also, no other country derived such great return in manufactured articles from its workers.

Russia and Spain, which stand lowest in the list of power-using countries (.15 horsepower per wage-earner), produced in value of manufactures only $440 and $361, respectively, per wage-earner. Fifteen foreign countries, including Canada, had in 1900 an average of .3 horsepower per wage-earner, of whom each produced an average of $519 worth of goods.

Pennsylvania during the year 1900 produced $1,834,790,960 worth of manufactured goods by the aid of 733,834 workers and 1,859,263 horsepower. For each wage-earner, aided by 2.54 horsepower, an average of $2,500 worth of manufactured articles was produced.

The following figures, being the statistics from which the figures in the preceding paragraphs have been taken, are of interest, as they indicate clearly the relation which exists between manufacturing progress and the use of power.

Countries.	Wage-earners.	Total horse-power used in manufactures.	Value of products.	Value of products per wage-earner.	Horse-power per wage-earner.
United States	5,308,406	11,300,181	$13,004,400,143	$2,452	2.16
United Kingdom	9,000,000	3,000,000	5,000,000,000	556	.33
Germany	10,000,000	3,400,000	4,600,000,000	460	.34
France	5,000,000	1,500,000	3,450,000,000	690	.30
Belgium	1,550,000	630,000	720,000,000	480	.42
Switzerland	600,000	320,431	300,000,000	500	.54
Austria-Hungary	4,700,000	750,000	2,000,000,000	425	.16
Russia	4,500,000	700.000	1,980,000,000	440	.15
Italy	3,600,000	900,000	1,700,000,000	472	.25
Norway	200,000	80,000	90,000,000	450	.40
Sweden	490,000	200,000	280,000,000	572	.41
Holland	460,000	130,000	245,000,000	540	.29
Spain	1,800,000	250,000	650,000,000	361	.15
Australia	550,000	460,000	500,000,000	900	.80
Japan	382,298	84,216	220,000,000	566	.22
Canada	550,000	750,000	800,000,000	1,455	1.36

POSSIBILITIES OF WATER-POWER DEVELOPMENTS.

A stream, as it applies to water power, is like a chain, only as strong as its weakest link. In figuring on the possibilities of water-power developments on an unconserved stream, we can only figure, practically, on the results obtainable from the minimum discharge of the stream, counting all in excess of this to be wasted, but in reckoning the power possibilities on our streams in Alabama, I shall show both the horsepower possible with the minimum flow and also the power possible with a practical conserved flow, from the fact that on the headwaters of our rivers, like almost all other rivers in the United States, there are found desirable reservoir sites at which reservoirs of sufficient capacity to answer all purposes can be economically constructed when compared to the benefits to be derived from them.

WATER POWER IN ALABAMA.

The following table will show the primary water power possible in Alabama, conservatively estimated:

	Horsepower.
Tennessee, with minimum natural flow	162,000
Tennessee, with practical conserved flow	396,000
Coosa, with minimum natural flow	120,000
Coosa, with practical conserved flow	360,000
Chattahoochee, with minimum natural flow	115,000
Chattahoochee, with practical conserved flow	230,000

It is probable the possible water powers on unnavigable streams will be about 10 per cent of that on navigable streams. This would give Alabama:

	Horsepower.
With unconserved streams	436,000
With practical conserved streams	1,084,000

This means that it would require, according to standard tables, 4,505,000 tons of coal per annum to produce by steam the power of these streams in their unconserved state, and 11,201,000 tons of coal per annum to produce by steam the power of these streams in their practical conserved state.

Alabama is producing to-day about 14,000,000 tons of coal per annum for every purpose. Thus it will be seen that it will take about 80 per cent of the entire production of coal in Alabama at this time to produce by steam the power of these streams that is now going to waste.

Suppose for a moment that the coal fields of Alabama were sliding down an incline and pouring off over a precipice into fathomless space at the rate of 11,201,000 tons per annum; how long would it take the people of the United States to get busy and try to stop such a waste of a God-given resource? Yet, what else are we doing when we sit idly by and let the water of these streams go to waste over a precipice, while we ourselves burn up the coal?

AID OF NAVIGATION BY STORAGE.

We have been considering in Alabama for a year or two a plan for the improvement of navigation on the Alabama River which contemplates the impounding of the flood waters on the headwaters of the Coosa River in Georgia, from which an increased discharge might be had to aid navigation on the Alabama River during low-water periods, which does not exist over sixty or ninety days at any one time, and this only occurs probably every eight or ten years.

Our studies and investigations looking to this plan of improvement are very interesting and from our present viewpoint promise splendid results, and is probably only typical of what can be done on many other streams.

The extreme low-water discharge of the Alabama River is approximately 2,000 cubic feet per second. This will give with the average slope of the river and the proper channel work, as contemplated over the shallow places, 4 feet of navigation. Six thousand cubic feet of water per second with the same width channel will give 8 feet of navigation. Therefore it follows that 4,000 additional cubic feet discharge per second from a storage system for a period long enough to bridge over the low-water stage of sixty to ninety days will make 8 feet of navigation on the Alabama River possible at all times.

Then, in addition to this, the 4,000 additional cubic feet per second, together with the natural flow of 2,000 cubic feet passing through the turbines over the rapids on the Coosa River, will give the maximum horsepower for power purposes as heretofore explained.

We find also on the headwaters of the Coosa River a number of desirable sites at which storage reservoirs can be economically constructed that will give the requisite quantity of water necessary, we think, to give these results, and at the same time the reservoirs will very materially lessen the impetuosity of the floods.

DR. CHARLES R. VAN HISE, OF THE UNIVERSITY OF WISCONSIN.

Doctor **Van Hise**. Representing the Conservation Commission of Wisconsin, I am requested, in the absence of the governor, to speak on one subject of the work of that commission which is apropos to the subject under discussion this afternoon, that of lands.

The subject to which I shall call your attention for a few moments is that of the phosphate of the soil. I select this particular subject because it shows the interrelation of the work of conservation in the several States. You may wonder why I, in Wisconsin, a State which has no phosphate deposits, should be especially interested in this subject, but the phosphate deposits is a matter in which every State is interested. Of the various elements of fertility in the soil, nitrogen, potassium, and phosphorus are the important ones. Combined nitrogen for the soil may be obtained from the atmosphere by methods which I need not discuss; potassium is present to the extent of 2½ per cent in the original rocks, and in some to three times that amount; and even if the natural concentrations be used up we shall be able, by sufficient expenditure, to use the original rocks as the source of potassium to fertilize the soil.

Phosphorus is present in the original rocks to the extent of only eleven-hundredths of 1 per cent. It is the element which is most crucial in the matter of soil fertility. Mr. Hill, at the conference last spring, told of the decreasing productivity of the grain fields, wherever the lands have been cropped for some time, not only in the Northwest, but in the various parts of the country. The most important chemical factor in the decrease is the depletion of the land in phosphate. You who are familiar with the situation in the upper Mississippi Valley may think that the wonderfully fertile lands there located have a sufficient amount of this element, and yet investigations recently made by the agricultural experiment stations of Ohio, Illinois, and Wisconsin show in these States that the element phosphorus has already been greatly reduced. So far as I know, the only quantitative studies which have been made are in Wisconsin. There Mr. A. R. Whitson has shown that the fields which have been cropped for fifty years have lost one-third of their phosphates. The director of soil work in Illinois is here to speak for the commission of that State and will supplement my statement.

There is absolutely no way of handling the land by which we can increase its content of phosphate. To increase its phosphate requires the addition of a fertilizer containing phosphorus. If the loss for the United States has been as much as one-half as much as it has been for the State of Wisconsin in the cropped fields for fifty years, a simple calculation shows the entire products of our mines at the present rate of production would be required for more than one hundred years to restore to the soils of the country their original fertility in phosphorus; and Mr. F. B. Van Horn, of the Geological Survey, who has made a careful estimate of the deposits of phosphate in Florida, South Carolina, and Tennessee, and a rough estimate as to the probable amount that may become available in the West, calculates that the supply of this element is sufficient to last for only about fifty years, even at the present rate of consumption.

Last month there was an announcement of the formation of the Franco-American Consolidated Phosphate Company, the capital of which is almost exclusively held abroad. This phosphate company has already purchased a large portion of the richest phosphate lands in Tennessee, which contain the largest supplies of phosphate of any State, with the exception of the western deposits. What is the purpose of obtaining these lands? Manifestly it is to ship our phosphates abroad to restore phosphorus to the depleted soils of Germany, France, and Spain, for all three of these countries are represented in the capital of that company. Gentlemen, it seems to me there should be a law which would prohibit the exportation of a single pound of phosphate from this country. We do not want an export duty in any case. We want prohibition. To allow our phosphates to go out of this country is nothing short of agricultural suicide.

Under modern conditions we are wasting annually enormous quantities of phosphate. A large proportion of the fertilizers produced on the farms which contain much phosphorus is allowed to wash into the streams and thence into the sea. Under our modern sewage system, by which we dump into the rivers the sewage, we are also sending an additional amount of that essential element to the sea. Here in the city of Washington to-day there is going down into the Potomac and into the sea this valuable fertilizer. Upon this point Mr. Whitson has made a rough computation and he estimates that through the sewage systems of the cities of the United States the equivalent of at least 1,200,000 tons of high-grade phosphate is lost annually. If the soil's fertility is to be retained, and upon the soil depends our food and clothing, this waste must be stopped. Of all the great questions which have come before this commission the preservation of the fertility of the soil is the most fundamental. We must in some way stop this criminal waste of our phosphates, for the amount exported is much less than the amount that is wasted by our improper methods of agriculture and sewage disposal.

Here is a great responsibility and a great opportunity for the governors of the States and the teachers of agriculture all over the country. The people must be taught to realize their responsibilities to posterity in this matter. They must be brought to understand that unless this element of phosphorus is conserved, unless soil erosion is controlled, the most fundamental of all our resources, the soil will become greatly depleted and will be able to sustain only a relatively small population.

You may ask the question, if the above statements are true, how is it that the crops grow well in China and Japan? In the densely populated parts of these countries practically all the fertilizing element produced by animals and by man goes back upon the soil. Where this is done the phosphate may be used over and over and over again and the fertility of the soil in phosphorus may be perpetually maintained.

I dwell upon this subject at some length because it seems to me to be one of the great fundamental questions before us. This is one of the questions which the commission in Wisconsin has taken up with reference to the interests of that State, but you can readily see we can not consider this matter in our State without thinking of the situation in the Southern States and in the Western States, where are to be found the natural phosphate deposits. No other subject shows more clearly how the future welfare of all the States interlock; how the nations and the States and the individuals must cooperate in conserving our natural resources.

MR. J. H. RICHARDS, PRESIDENT OF THE AMERICAN MINING CONGRESS.

Mr. **Richards**. My friends, as I stand here facing you at this moment, I am again impressed with the idea that there is nothing so certain in human life as the unexpected. I had prepared to leave your city, and was about to leave when I was requested to contribute my mite to the great thought force you are undertaking to set in motion and disseminate throughout the country from this center.

My peculiar relation to the mining thought of this nation within the last seven years is the only justification for attempting to occupy your attention even for a moment. In my efforts as president of that organization to give direction to the mining thought of this country along lines that are in harmony with the purposes of your meeting, I have been impressed with this idea, that we can not deal here with details, but only with those fundamental questions that have been implanted in the human heart from the beginning; that they may be promulgated and sent out to the American people from this important meeting.

We create nothing. We simply discover the true basis of human growth which existed from the beginning, promulgate or set it in motion, then apply it to our needs.

Ideas rule the world, and should rule it. This was impressed upon me when the ideas, implanted in the human heart from the beginning, found expression in the dawn of our country's life, when our fathers promulgated and applied to our needs the great constitutional and legal foundations upon which this country must rest for all future time. It was again illustrated, and showed how deep the roots of those great ideas are planted in American hearts, when the strength of this nation was tested, when the constitutional rights that had been established were tried, and again established and forever. As a result of that contest we came to realize, through personification of American manhood in the form of Abraham Lincoln, that we are a united nation and that we all stand equal before the law. Our country was established and preserved upon that theory. At this time the third important crisis in the history of our nation confronts us, when in order to insure our continued and stable prosperity we must develop our wonderful resources along the constitutional lines that have been laid down for us by those who have gone before.

This development must be nationalized and promulgated from this center of thought. We can then coordinate and utilize these various local resources.

I am impressed that we must send out over the country the thought that we believe the time has come when in meetings of this character we must try to direct, through cooperation, coordination, and conservation, the use of our national bounties.

Nature has been so generous in her bounties that it takes a generous heart to interpret and cooperate with her in developing our industrial possibilities, and at this time we must send out from this center thoughts that are in harmony with the idea of cooperation, coordination, and conservation, but at the same time in harmony with our constitutional and legal basis upon which our development must rest.

As president of that mining organization, these are the things that have been impressed upon me now for seven years. It has been my hope that there may be impressed upon the mining thought of the day the central point of your purpose in meeting here, and that is, all we attempt to do must rest upon the constitutional and legal basis upon which our Government is founded and upon which our national development must rest.

I have received inspiration from your chairman, and I love him for what he is to this nation; and now, since I have had the privilege of meeting his mother in this hall, I have no doubt why he is what he is.

I want to leave this one thought with you, resulting from the experience of seven years in this character of work: That we must nationalize and promulgate this idea of conservation of our natural resources in harmony with our constitutional basis, and then coordinate all of the state and local forces into one grand, harmonious whole; because I am convinced that underneath all the changing scenes of our material development there is the everlasting foundation of scientific truth. Aside from the waste of natural resources, the waste of human life must be considered—and this is a thought that was made prominent at our convention at Pittsburg—the man under ground must have the same legal and constitutional protection as the man above ground. We can not carelessly sacrifice human life longer upon the altar of industry. We must remember that the capacity of the American citizen to achieve and enjoy the fruitage of his industry is the greatest asset the nation has. And out of this great industrial development that is now just beginning to dawn upon the world there will come that moral and spiritual uplift of the American people which will be the crowning glory of American civilization.

EX-GOVERNOR NEWTON C. BLANCHARD, OF LOUISIANA.

Governor **Blanchard**. Mr. Chairman and gentlemen of the conference, I, too, like our friend who has just addressed the conference, am expecting to take my departure this evening from the city of Washington, and before I go would like to address a few words to the conference.

I have been here now for nine or ten days, hard at work with other members of the National Conservation Commission and the experts in the preparation of the report which was read this morning. It has been to me a work of great interest and instruction.

I was much pleased with the admirable address delivered before this body earlier in the day by the distinguished governor of the State of Minnesota. So optimistic, however, were his views relative to the supply of certain of the natural resources of the United States that it set me to thinking that if he be not mistaken in what he said, why has the National Conservation Commission existed at all? He told us, in direct contravention to the carefully prepared report of the National Conservation Commission—and that report is founded upon information supplied by the government experts—that there is iron ore enough in the State of Minnesota alone to last this country for centuries. The report of the commission declares that, so far as the high-grade ores now in use are concerned, the middle of the present century will see their exhaustion; and that so far as the low-grade ores are concerned (the ores which must come into use after the high-grade ores are exhausted), their exhaustion may be looked for not much later than the end of the present century.

I am informed by the Director of the Geological Survey that the estimates of the supply of iron ores which he and the experts of his bureau submitted to the commission were made after the most careful and elaborate study, and that the estimates thus submitted were concurred in by state geologists and mining engineers who were called into conference.

I am further informed by the director that in the estimates which were submitted to the commission, and upon which the commission's report is based, there were taken into consideration all of the ore deposits in the State of Minnesota, and that to be on the safe side—that is to say, not to underestimate—a billion tons more were added to the estimates submitted of the quantity of iron ore in Minnesota than the officials of the State of Minnesota themselves placed upon the same.

The tax commission of the State of Minnesota estimated the iron ore in the Mesabi and other ranges in Minnesota at a billion tons less than the figures submitted to the National Conservation Commission by the federal experts.

So that, with due deference to the governor of Minnesota, whose speech, without intending it, challenged the accuracy of the report of the conservation commission on an important point, I beg to submit that it is more likely the reports of the government officials, men who have been giving close study to this matter for years, and particularly so since the appointment by the President in June last of the National Conservation Commission, are more apt to be correct in the estimates they give than are the reports from other sources whence came the information upon which the governor based his statement.

Now, answering in part the inquiry of Senator Newlands, as to what has been done by the several States since this question of conservation has assumed national proportions, I wish to say that in my own State of Louisiana, by authority of law enacted since the President called the governors in conference in May last, a state commission on conservation has been appointed and is beginning its work of taking an account of the natural resources of the State. In that connection I will repeat to the gentlemen who are here in conference with the National Conservation Commission some things about the resources of Louisiana that I stated to the commission itself during its sessions in the last week.

Strange as it may seem for a State lying as low upon the Gulf of Mexico as does the State of Louisiana, she ranks quite high upon the list of mineral-producing States. We have no coal and iron, none at least that have been discovered as yet; nor have we gold and silver. We have no copper, zinc, or lead. But we have what is now thought to be by scientists the most remarkable supply of natural gas yet discovered.

In the Caddo field, in northwest Louisiana, there are gas wells that are attracting the attention of the world. Some of these wells have been burning for three and a half years. A German expert who came over to this country recently, charged with the duty of looking into the natural gas and fuel oil conditions in the United States, visited the Caddo field in Louisiana and reported that there were being wasted there by "wild" wells as much as 70,000,000 cubic feet of natural gas a day—enough to supply each day the needs of ten cities the size of Washington.

Then we have in the same field, perhaps, as great, if not a greater, deposit of fuel oil than has yet been discovered in the United States.

There are individual wells in the Jennings field, in southwest Louisiana, that have a record of having produced more than 3,000,000 barrels of oil each, and are still producing. I have been told by geologists that there are no wells elsewhere in the United States with any such record of production as that.

Since I made that statement to the National Conservation Commission, Congressman Broussard, of Louisiana, whose district includes the Jennings field, tells me that I underestimated the production of some of the wells in that field.

Then, we have in Louisiana the greatest sulphur mine ever discovered in any country in any age. It is a fact that Louisiana sulphur to-day is supplying the needs of the world for sulphur. We are underselling in the markets of Europe—even in Italy—the Sicilian production of sulphur.

And then, in the matter of rock salt, 99 per cent pure, there are deposits in Louisiana through which the drill goes for 2,200 feet without touching the bottom. This salt is found over a large area of the low-lying lands upon the Gulf of Mexico within the limits of the State of Louisiana.

And then, gentlemen of the conference, in the matter of lumber production Louisiana is next to the State of Washington. Our forests of longleaf pine and of shortleaf pine are very extensive. Cotton, corn, sugar cane, and rice grow on our rich lands in equal luxuriance in the same 50-acre field.

So that it is a State just now realizing what it has in the way of bounties bestowed by nature. Public sentiment is being aroused there, and it is not necessary to say to gentlemen of the intelligence of those before me that if we are to carry through this great policy of conservation of the natural resources of the country the first and foremost thing to do is to educate the people as to the facts of the wastefulness of the supply now going on and of the duty of this generation and coming generations to preserve these resources and hand them on down unimpaired to future generations, for it is only by such education that a popular sentiment so necessary to put behind this movement can be developed.

Forestry—how to preserve our forests—is attracting much attention in the Southern States. But very little is known of the subject, and the practice of forestry is next to nothing. Information, facts, lectures, education along these lines are needed. If only the legislatures of the States, when they meet, would extend invitations to the Forest Service of the United States Government to send men skilled in this service to talk to them, to appear before committees, much might be accomplished in pointing the way to useful legislation.

The average legislator has not had the opportunity to know about these things. He has been busy with other matters. He is too busy to read the pamphlets on forestry sent him. He goes to the capital with the idea that something ought to be done, but with no practical plan for the doing of that something. He needs to be told; to have the way pointed out to him.

Of course, the federal authorities would not think of going into a State, or into the capital of a State, when the legislature is in session, in connection with the matter I suggest, without an invitation. They are careful always to avoid the criticism of interference on the part of the Federal Government with state affairs. But if the governors or the legislatures of States, desiring knowledge about this, wanting lectures delivered giving facts and figures, would suggest the coming of experts or trained men, I do not doubt that the several departments or bureaus of the Federal Government would be willing to respond by sending men who would appear before the appropriate committees and give the practical instruction so essential to the making of progress in forestry.

The report of the National Conservation Commission and the papers forming the appendix thereto should be read by every intelligent man and woman in the land. But how many will read them, or get the chance to read them? Literature of that kind is difficult to get out among the masses of the people. Even when sent out, how many of those into whose hands they come read them?

But if the legislature be in session, and a man who knows the facts and figures and can talk them appears, he will be listened to. All that is necessary to develop the public opinion, so necessary, is for the facts to be disseminated generally among the people.

MR. J. N. TEAL, CHAIRMAN OF OREGON STATE CONSERVATION COMMISSION.

Mr. TEAL. Mr. Chairman, I will make a very brief report. While you all doubtless would be very glad to hear about the resources of Oregon, and I would be delighted to tell you about them if I had time, the hour is getting late and I do not consider that to be the particular purpose of this meeting.

The governor of our State appointed a commission, of which I had the honor to be elected chairman. That commission has prepared a report, printed it, and filed it with the National Commission. There are some of these reports here, and if any of you gentlemen desire copies or have any interest in the method by which we looked into this subject, I shall be delighted to have you take one of the reports, and from a reading of it you will doubtless discover how ignorant we are of the resources of our own State, and, possibly, the reason why I do not care to talk more about them. There is one thing, however, we discovered, which doubtless any commission will discover when it goes into the matter, and that is the enormous and almost wanton waste of our natural resources. Without going into that question, I think it is conceded generally that such is the fact. It is also conceded that this waste must cease. Another question, one of law, which should be conceded (and if not acknowledged sooner or later there is little good of going further) is one upon which we can all work with safety, and that is in dealing with these public resources we are in effect trustees, and we have no more right to dissipate the principal of the fund that has been temporarily placed in our hands than a trustee under a will or a guardian has a right to dissipate the funds of an estate or of children in his charge or control. In my judgment this is fundamental. To illustrate, take a water power, which is certainly a natural resource. To think a legislative body, by its mere ipse dixit, can make it possible for one to acquire a fee-simple title to such a power in perpetuity is shocking. If such is the law as applying to existing rights, then provision should be made to prevent such a condition as to powers which the State and nation still control. I do not mean by this that "powers" any more than other resources should not be used. I would promote a free use, but it should also be a beneficial one. In my opinion the monopoly of water powers should be made impossible. But I am not discussing these questions now. It is easy to talk of generalities and it is easy to pass resolutions based on them. I believe in the conservation of our natural resources. How are we going to conserve them? In my judgment, before this convention adjourns, some practical scheme should be devised, some basis upon which we can all act hereafter. I would recommend that a resolution be offered by some of the governors and adopted covering the following suggestions:

First. That the National Conservation Commission be made a legal body, resting upon the same basis of authority as any other department of the Government, with sufficient funds to enable it to carry on its work properly.

Second. There should be the closest relationship between the States and the General Government. The States, through their governors, should be the connecting link between the National Conservation Commission and the state conservation commissions, and the powers of the State and of the nation should be coordinated and work together.

If we do that, and follow it up by action, we will have taken an important forward step and will have the consciousness of having made an honest effort to pass down to the future, unimpaired, the trust which has been placed in our hands, and preserve for the future our great natural resources, which should and can be made a source of comfort, wealth, and happiness forever.

PROF. G. E. CONDRA, CHAIRMAN NEBRASKA STATE CONSERVATION COMMISSION.

Professor Condra. Mr. Chairman and members of the commission, I will speak briefly for Nebraska as Governor Sheldon's representative.

It has been my privilege and duty during the past fifteen years to study the geography and economic geology of our State. This experience has caused me to reach certain conclusions pertaining to Nebraska's resources and possibilities. Let me refer briefly to some of the Nebraska conditions, because reference has been made to the same by preceding speakers. Our State is large, diverse, and as a rule, rich. It has large areas of both fertile and poor land. Forty thousand square miles of an agricultural region in the east and south countries, being eight times the area of Connecticut, are well developed, with its land ranging from $75 to $150 per acre in value. The day of homesteading has long since passed in this part of the State. Now, its landscape presents a continuous view of alfalfa, wheat, corn, and modern farm buildings.

Lying to the north and west of our most prosperous agricultural area are about 20,000 square miles of sand-hill country, covered for the most part with a thin stand of native grasses. I know that 640 acres of the average of this will not support an American family. If this statement is correct, then the Senator who wishes to restrict homestead to 320 acres in this locality is probably wrong. The soil contains little humus; it is not strong. There is a lack of the necessary elements and conditions for the successful growth of the common crops. Grazing is the leading industry, and for this purpose the region is moderately well occupied, most of the hay flats being deeded land.

The western part of our State, occupying more than 12,000 square miles of the high plains region, is good and bad. It is a place where the influences of rainfall, structure, soil texture, and irrigation water are most marked, and the home of the various forms of reclamation. I can take you to certain localities in this region where good crops of wheat, oats, alfalfa, and potatoes are produced under a low rainfall without irrigation. It is where the soil is close textured and deep. Popularly such cultivation is known as dry farming. Near these fertile places occur sandy soils, underlain by bedrock near the surface, on which crops do not withstand drouth. Some of this land is better adapted to grazing than to any other purpose. Notwithstanding this fact, the native sod on many acres of this strictly grazing land has been turned by would-be farmers. In marked contrast to these high, dry, sandy lands are the many thousands of acres now in successful irrigation, especially along the North Platte.

Gentlemen, it appears to me that our first duty along the line of the conservation of land resources in Nebraska is to obtain a deep insight into the agricultural conditions and possibilities of each of our four soil regions, and that our second duty, sometimes an unpleasant one, is to tell the exact truth of these conditions and possibilities, so that homesteaders and homeseekers, mostly from the East, may come knowingly into their new environs and adapt themselves accordingly. Grave misfortunes result from the settlement of an unfavorable region by an agricultural people. Too many citizens now leave their fertile fields and happy homes, through ignorance and misrepresentation, and find their way to places where the possibilities of disappointment and failure are altogether too great. It appears to me that the Federal Government should investigate and make known both the favorable and the unfavorable conditions that obtain on public domain preceding settlement. And I believe also that each State, in cooperation with the Federal Government, should investigate and publish for the free use of its citizens, something concerning the nature, efficiency, possibilities, and impossibilities of each class of land now occupied, so that farmers may have a proper basis for farm management, leading to the conservation of soil fertility, a thing which is necessary for the future of our agricultural industries.

Having spoken plainly concerning these matters, you will please permit me to say a word on a subject which was discussed at length by the gentleman from Minnesota. It is in regard to the supposed increase in rainfall and the westward movement of the rain belt. This subject comes close home to persons living in western Nebraska. Four times, during periods of heavy rainfall, coming at intervals of eight and twelve years, have the people of Nebraska and adjacent States moved onto high, dry lands, believing in the fallacy of an increasing rainfall. The experiment has proved a costly one, resulting in the establishment of a permanent agriculture only in the most favored places. The facts are, that there is fluctuation in rainfall, but no permanent increase. It returns to about the same mean, if we average the wet and dry periods. However, we have learned that the amount of rainfall is not a complete check or control of agricultural development. The climate of the soil, not of the air, is more important. This varies with soil type, is related to the quantity of rainfall, and affected by cultivation and the kind of crop. This changed climate of the soil, resulting from cultivation and other conditions, is probably what most people mistake for an increasing rainfall.

Now, the matter of fluctuations of rainfall prevails throughout most, if not all, of the United States, but the effects therefrom are most marked in the drier regions, as in parts of Nebraska, Kansas, Wyoming, Colorado, New Mexico, Oklahoma, and Texas. The phenomenon has a close relation to farm management and to the agricultural practicum on the least drouth-resistant soils of these States. Let us meet the problems of soil conditions and of climate, as such, with a farm management that is suited to the nature of these conditions, for these and other related factors must be reckoned with in the establishment of permanent industry in that part of the country.

As regards conservation work in Nebraska, I wish to state that our governor has decided to appoint a commission to be composed of scientific men actively engaged in a study of the State's natural resources. Most of these men head departments in the State university. They are free from politics and in a position to stand strongly for any policy that may seem best for the permanent good of the State. We propose to work along the line of our leading interests, which are largely agricultural. One of our largest problems appears to be the conservation of soil fertility of the rich farm lands. We expect to investigate soil erosion and to advocate crop rotation. Among our other problems are those of the proper management and utilization of flood lands, steep slope lands, sand-hill areas, bad lands, and the high plains areas. Our farmers begin to realize that they should give more attention to the natural and the proper distribution of forest, grass land, and the cultivated crops if the land resources are to be conserved.

Nebraska is large enough and rich enough in her agricultural resources to stand on her own bill of facts, without any attempt to overdraw her possibilities. Her citizens believe in research. They understand the importance of cooperation and the economic utilization of our national resources, both State and national. To this end they join heartily in the great movement in which we are engaged.

DR. J. T. ROTHROCK, CHAIRMAN OF PENNSYLVANIA STATE CONSERVATION COMMISSION.

Doctor **Rothrock**. I wish to say that the governor of Pennsylvania has responded to your call for the appointment of a conservation commission. There are five of us here ready to cooperate with you in any way that seems possible. But I wish to say, first of all, that this conservation business is not a new thing in Pennsylvania. For more than twenty years the State of Pennsylvania has been on the firing line.

Twenty years ago a forestry association was organized in the State of Pennsylvania. To-day, as a result of that forestry association, we have nearly 1,000,000 acres of land purchased from the citizens of the State and turned over to the State as a forest reservation.

I wish to say the people of Pennsylvania are so thoroughly in earnest about this matter that they have paid more to get that land back in a stripped condition than the State received for it when it was sold with heavy timber on it.

We are in earnest up there. We believe in this conservation work.

I wish to say, furthermore, that we are taking in young men from over the State to make foresters of them. We do not know what their politics may be; we do not care what their politics are. We put those young men through a preliminary examination, first, physically, to see whether they are able to stand the duties of the forest service, then a mental examination, and then at the expense of the State of Pennsylvania we educate them, just as young men are educated at Annapolis and West Point. They are to be the servants of the State. Three years after their graduation they give their time to the service of the Commonwealth. We are in earnest about the education of our corps of foresters who are to care for this state land.

We furthermore recognize that you can not get a people to take up the abstract idea at present of forestry as a thing which is desirable. A great many people do not understand it. A great many do not want to understand it. But we invite the public out into our lands.

There is no prohibition there to keep off of the grass; to keep out of the grounds. We invite them in. You can not get people interested in land, even land that belongs to them through the State, unless they are taken out into it.

We have opened upon our reservation a sanitarium, and this year $1,000,000 has been invested by the State of Pennsylvania for the erection of a sanitarium for tuberculosis on state ground, ground that belongs to the people of Pennsylvania.

These are just some of the things we are doing there. We have published a little journal in the State of Pennsylvania for over twenty years now. It goes broadcast over the State, and, we may say, almost without subscriptions. It is practically freely distributed.

Mr. President, I do not want to take your time. I simply call your attention to the fact that the State of Pennsylvania is already in line. All its preliminary work is done. Our decks are cleared for action, Mr. President, and we simply await the order to go ahead.

Senator SMOOT. I would like to call the attention of the convention to the fact that it is now five minutes to 5 o'clock, and there are a great many here who may have made arrangements for other meetings, and I would therefore like to move that we now adjourn until to-morrow morning.

The CHAIRMAN. Two or three have been recognized and we might hear from those first. At any rate, I shall ask your indulgence to make an announcement or two before adjournment is taken.

Senator SMOOT. I will withdraw my motion to adjourn, then, for the time being.

The CHAIRMAN. I wish to make two announcements. The request was that the committee consisting of the present governors and the past governors and the governors-elect meet here immediately at the conclusion of this session.

The committee on presentation of the waterway matter to the Senate Committee on Commerce will be appointed to-morrow morning. In the meantime I ask all state delegations to give me the names of their representatives.

I heard from Judge Richards, this afternoon, the only valid reason that has been given in the last two days—the only good reasons—why anybody should have a good opinion of me. I have had far more credit, gentlemen, than ever belonged to any one man, and most of what has been said about me really should have been said about men who have been doing more good work along this line than I have—Doctor McGee, Mr. Price, Doctor Holmes, and Mr. Woodruff, Mr. Shipp, and a lot of others.

They are the men that ought to have had the credit, and not me. Now, it is needless to say that I court your good opinion.

I see but one way that offers a fairly certain route for me to get it; that is, I want you all to meet my mother, and it would give my mother and me very great pleasure if the members of the conference would do us the honor to come to our house to-morrow night at 9 o'clock for a thoroughly informal reception. It is not a dress occasion. I want you to come up there and give her the pleasure of meeting you, and I think I may fairly say, give you the pleasure of meeting her.

I now recur to Senator Smoot's motion. It has been moved and seconded that this conference now adjourn until 10 o'clock to-morrow morning.

(The question was taken and the motion was agreed to.)

(Accordingly, at 5 o'clock p. m., the conference adjourned until Thursday, December 10, at 10 o'clock a. m.)

THURSDAY MORNING, DECEMBER 10.

The conference was called to order at 10 o'clock a. m. by the chairman, Mr. Pinchot.

The CHAIRMAN. Gentlemen, before we proceed with the consideration of the subject of forests, which Senator Smoot, chairman of the section of forests of the National Conservation Commission, is to present, I have to announce the appointment of a committee of this conference to attend the meeting of the Senate Committee on Commerce to-morrow morning at half-past 10 o'clock at the Capitol. I shall ask Governor Deneen, of Illinois, Governor Johnson, of Minnesota, and Mr. William K. Kavanaugh to form the special committee of three which I was directed to appoint. I have received nominations for the general committee from the following States: Rhode Island, New Jersey, Alabama, Colorado, Tennessee, Kentucky, Georgia, Wyoming, Indiana, Pennsylvania, New York, West Virginia, Missouri, Utah, Virginia, Mississippi, California, and Michigan, with other state delegations yet to hear from.

There is a great deal of business to come before us to-day, and I venture the suggestion to the conference, which will do with it as it may please, that you instruct your chairman to limit the speakers to ten minutes. If you do this, I shall take the liberty of disregarding your instructions in the matter of the governors who may address us, but I shall strictly keep everybody else within the limit.

(Upon motion, the suggestion of the chairman was adopted.)

SENATOR REED SMOOT, CHAIRMAN OF THE SECTION OF FORESTS, NATIONAL CONSERVATION COMMISSION.

The CHAIRMAN. I have now the very great pleasure of presenting to you Senator Smoot, of Utah, chairman of the section of forests, who will present that part of the commission's report to you for your consideration.

Senator SMOOT. Mr. Chairman, governors, and members of the state and national conservation commissions: I take it that we are here this morning for the purpose of considering seriously the vital questions affecting the conservation and the proper utilization of the forests of our country. It is a subject greater than any man, greater than any State; it is as great as the nation itself. Every man, woman, and child of to-day, and every one yet to be born, is interested in this great question. You no doubt have noticed that in all the previous discussions of this conference the question of the conservation and the use of the forests has played an important part. In my remarks I do not intend to call special attention to any of the great resources of any particular State, because there is not a single governor here or state representative who could not sing the praises of his own State and speak of the wonders of its natural resources. I wish to present to you and emphasize, if possible, some of the points that have been made in the report of the National Conservation Commission, which report I hope will be approved by this conference and then submitted to the President of the United States.

God has blessed this beautiful land of liberty most lavishly and richly; no country on earth has been given so many natural resources, and it seems to me that in the past we have been lax, indeed, in trying to preserve them not only for ourselves but for future posterity.

Gentlemen, yesterday you heard the report of the committee wherein it was stated that an inventory of our forest resources had just been completed, which is the best we have ever possessed. This inventory is the result of the combined and vigorous effort of all state and federal agencies concerned.

The facts which flow from this great accumulation of knowledge regarding our forests will soon be made common knowledge, as they ought to be. From these facts three great conclusions spring; the first, that the forest problem before the individual, the State, and the nation is grave and urgent; the second, that we can solve this problem if we act unitedly, vigorously, and at once; the third, that if we fail to act, the possibility of a satisfactory solution will be rendered doubtful or even wholly removed. The time is past for us to be content to dabble with the vital internal question which the right handling of our forests presents. It may well be our pride that no nation has a more wholesome and enthusiastic public sentiment for the right use of the forests than our own, but it may well be our shame that no nation takes poorer care of its private forests than our own country.

This is not the time for harsh criticism of the agencies which have brought about the deplorable condition of our forests. But above all it is the time for prompt, effective, and united effort to remedy this condition. The time has long past when the only need for the conservation of our forests was in order that we might fulfill our duty to those who come after us. The time is already here when for our immediate welfare the conservation of all forests in private as well as in public lands is absolutely essential. Forestry no longer makes its appeal to the American people solely through their sense of public duty. Its appeal now rests upon a firm foundation, not only of public duty, but of urgent industrial and commercial necessity.

I wish at this time to call your attention to some of the special items of that report again, so that you may each be impressed with the importance of this particular fact.

Consider the situation. This nation began with half its area under forest. To-day barely one-fourth of our country is covered by forest growth. Only one-fifth of the standing timber which remains is in public ownership, and therefore belongs to the people. Four-fifths of what remains is in private hands. Year by year we take more and more wood from our forests, and year by year by careless cutting and by fire we lower their capacity to produce again. The yearly production of our forests by growth is 7,000,000,000 cubic feet, a volume of timber so great that the mind can scarce comprehend it; but a volume of timber over three times as large is taken from our forests each year. Nor is this the complete indictment against us as a nation for our misuse of the forest. We invite by overtaxation the destructive handling of forest lands. We should plant, to protect farms from wind and to make stripped or treeless lands productive, an area larger than Pennsylvania, Ohio, and West Virginia combined. But so far lands successfully planted to trees make a total area smaller than Rhode Island.

It seems to me one of the most destructive elements of our forests comes from forest fires, and if the governors can in any way educate the individual who owns the forest upon this point of view, this meeting will not have failed. I was visiting the Appalachian country a short time ago and had the pleasure of inspecting the great Biltmore estate. One of the party asked Dr. C. A. Schenck, the forester in charge, if he had $5,000,000, the interest on which was to be used by him for the preservation of forests, what he would do with it. His answer was without hesitation, "I would use every dollar of it for a fire patrol." Asked again if he had the interest on $20,000,000 what he would do with that, he replied, "I would increase my fire patrol just four times."

Since 1870 forest fires have each year destroyed an average of 50 lives and $50,000,000 worth of timber. Not less than 50,000,000 acres of forest is burned over yearly.

One-fourth of the standing timber is left, or otherwise lost in logging. The boxing of the long-leaf pine for turpentine has destroyed one-fifth of the forests worked. The loss in the mill is from one-third to two-thirds of the timber sawed; the loss in the mill product, through seasoning and fitting for use, is from one-seventh to one-fourth. The damage done by destructive forest insects is enormous and largely preventable. Only 320 feet of lumber are used to each 1,000 feet which stood in the forest.

Nor is the indictment yet complete. By the needless destruction of our forests we impair the value of our streams for navigation, irrigation, water supply, and power. We spend millions of dollars in river and harbor improvements to repair damage which, at the cost of mere thrift and foresight could have been nearly all avoided. We deal with the effects and ignore the cause. We discuss the exact scientific relation between the forest and the stream, when each year the total quantity of silt carried by our rivers as the result of forest denudation and poor soil management would cover 1 foot deep a surface of more than 900 square miles. In our blindness we have failed to take advantage of the lessons which the history of other nations contains. Most other countries have learned through bitter experience that forests which are not conserved will be used up, and they are taking care of what they have. We are among the last to learn it.

So much for the indictment. Every clause in it is absolutely true. What would you think of the business capacity and the foresight of an individual against whom such an indictment might justly be read? So much for where we stand. Now let us consider what must be done, and where we might stand if it were done.

These are the things which we must do; they involve no intricate machinery of law or practice; they are simply incontrovertible conclusions based upon the conditions which now exist and which must be remedied: First in importance is the conserving of forests in private lands. Private forest owners, which means 3,000,000 men, and individual forest users, which means everyone, must practice reasonable economy in the woods in logging, in milling, and in the use of timber. Above all they must protect their forests from fire. This they can do at an annual cost equal to one-fifth of the damage forest fires do each year, not counting injury to young growth. And it is this young growth which, if preserved, would grow a constant supply of timber for those who come after us. I do not ask of the private owner and user that he apply any economy which is not entirely practicable, and which does not mean present as well as permanent profit. I ask only that he protect his forest from fire, that he log it conservatively, and that he plant uplands suited only to forest which have been so denuded of trees that they now fail even to pay the taxes levied upon them. To justify private owners in applying those measures, two main conditions are necessary, both of which exist to-day: The one, a knowledge of the central fact that these measures are needed and that they will pay; the other, the availability of knowledge as to how these measures may best be applied. If anything I could say to the governors to-day that seems more important than another, it would be to return home to your States and educate the people.

One of the urgent tasks before the States is the immediate passage of tax laws which will enable the private owner to protect and keep productive under forest those lands suitable only for forest growth. In our discussion in committee meeting there was a question raised by a member present as to this recommendation, claiming that it would encourage great monopolies in securing larger holdings of timber, if an annual tax was not required on the timber itself. I have studied this question in foreign lands, particularly in Germany and Switzerland, and I find that the result has been exactly the opposite. It does seem to me that the great monopolies that control vast tracts of our timber land can much better afford to pay an annual tax on their timber than can the individual man with scanty means at his command who believes in reforestation and upon whom such a tax would be a burden so great that it would be almost impossible for him to carry it. I believe, with all my soul, in the tax laws as recommended in our report. It is a shortsighted policy which invites, through excessive taxation, the destruction of the only crop which steep mountain lands will produce profitably. Taxes on forest land should be levied on the crop when cut, not on the basis of a general property tax—that unsound method of taxation long abandoned by every other great nation.

Another urgent task before every great forest State is not only the passage of adequate fire laws, but their actual enforcement. More is needed to protect the forest from fire than a law upon the statute books. It requires the definite commitment of all the States to their inherent responsibility for the protection of the forests within their boundaries from fire, and that entails, and absolutely entails, the employment of a trained force whose first duty is fire patrol. A few days ago I heard a very prominent gentleman from West Virginia testify before the National Conservation Commission that the forest fires of West Virginia alone this year have cost that State, in the loss of timber, $5,000,000. A fire patrol that would cost the State of West Virgina $100,000 would be ample to protect that State against forest fires. Think of it, gentlemen, the loss in this one year in the State of West Virginia was sufficient to patrol that State for its protection against forest fires for fifty long years.

The nation, through the Federal Government, confronts the urgent duty of conserving all, not merely a part, of the public forest lands by use. Until this standing timber is adequately protected and conservatively used, not only as at present on national forests, but on all other public forest lands as well, its very existence is imperiled. Grave injury has already been done. It would be a national disgrace should it continue.

I have recently visited that great and beautiful forest region which lies within the southern Appalachian Mountains, and I have this to say regarding the proposed purchase of a small portion of it by the Federal Government for the permanent use of the whole people. I believe as firmly as I believe that I am standing here on this platform that unless adequate action is taken, and taken soon, the destruction now going rapidly on in the Appalachian Mountains will either become irretrievable, or retrievable only at an expense so vast in time and money that it would stagger this nation. I do not believe that it is necessary or advisable for the Federal Government to acquire all mountain forests in this region, nor half of them, nor a fourth of them. The purchase of one-twentieth of these mountain forest lands, their protection from fire, and their conservation by use, would solve, and solve satisfactorily, this grave and urgent problem. But this entails, as every other effective national measure for the preservation of the forest entails, for its success, the cooperation of the State concerned, through fire protection, and of the private forest owners concerned, through better handling of forest lands in private ownership.

These are the incontrovertible conclusions which flow from the knowledge of how we stand along main lines with relation to the forest. Unless we do these things our forests will inevitably fail, and the failure of our forests means the erosion of soil upon the mountains and a falling off in the usefulness of our streams. Action upon each of these conclusions requires no vast expenditures, no upheaval in present economic conditions, but merely the exercise of reasonable foresight and thrift by individual forest owners and users, by all the States, and by the nation. No one of these great agencies can alone solve our forest problem. They must work together, unitedly, vigorously, adequately, and at once. If they act together and now, we need not worry greatly about our future timber supply. If they fail to act, it will mean inevitable and grave timber scarcity in the near future and actual timber famine for those who come after us.

We can no more disregard in our use of the forest than in our use of the mine, of the stream, and of the farm the fundamental truth that want follows close upon the heels of waste. But we should be thankful as individual forest owners and forest users, thankful as individual States, and thankful as a federation of States that the time for the application of an adequate remedy is not wholly past. Grave injury has been done to our country, which can not be repaired in a year, nor a decade, nor wholly effaced in a century; but the fact gained by our present inventory, above all other facts in importance, is, that if we act at once we still have forest enough left to produce, under right management, at least what timber we need.

The cause of practical forestry is a just cause. On the one side are established habits of wastefulness and of misuse; on the other side is the doctrine of common sense, of business sagacity, of public duty. Because I believe in the American people, I believe that they will follow the right course and turn away from the wrong in this, as in all other crucial questions upon which depends the permanent welfare of our country.

MR. ROSEWELL PAGE, OF VIRGINIA.

The CHAIRMAN. I will now call upon Mr. Page, of Virginia, for a statement of Virginia's views upon the questions we are considering to-day.

Mr. PAGE. Mr. Chairman and gentlemen, members of this conference, I want to say, as the representative of the governor of Virginia, how sorry he is not to be present at this great conference; but certain engagements, which had been made previously, prevented his being here, and he has done me the honor to send me here to represent him. I desire to say, as a representative of old Virginia, that on yesterday I was a little aggrieved at the tone which was exhibited by the governor of the great State at the mouth of the Mississippi towards the statement made by the governor of the great State at the head of the Mississippi. I felt as if I had a right, coming from old Virginia, which has had such an interest in those two great States, a historical fact to which I need not further refer in this presence, to say, "Remember that ye be brethren." I felt, furthermore, that I would like to say in behalf of this great conference that it would probably be apt if we could understand that each in speaking of his State is a little inclined to be as an old friend of mine said about another friend of mine, "a little paradeful." Therefore I thought it would be just to say to the distinguished governor of Louisiana that I think he was almost as exuberant with reference to that salt and that sulphur of his State as was the governor of Minnesota with reference to the iron in the Mesabi Range.

I am informed of the fact that to-day the subject is that of forests, while on yesterday the whole range of sky and earth and under the earth was taken when the subject was lands. I think to-day, inasmuch as we only have ten minutes—at least those who are not governors—perhaps we will have to stick to our text. You will remember the old story. Down in Virginia—I have told this story before—an old colored man was asked if he were a preacher. He said "No, I am a 'zorter." Being asked what he meant by an "exhorter," he replied: "If you are a preacher, you have to stick to your text, but if you are a 'zorter, you can branch."

The governor of Virginia has already appointed a distinguished commission. I shall not undertake to give to you the result of the work of that commission, but it will be furnished to the chairman of this conference in order that it may have a fit place among the records of this meeting.[a]

I can simply say this, that I am perhaps one of the few delegates to this conference who really, from necessity, should be an expert on forests, because I live in the woods. I consider it a great fortune to be able to-day to do that, and I also can say to you that there is great need of the preservation of the forests. I have known it to be the case that an acre of fine walnut timber has been cut down in the mountains of Virginia to enable them to sow buckwheat, and I am reminded of the fact of a distinguished friend of mine who, after forty years, took his wife on a bridal trip and they came to one of the great cities. A young furniture dealer was showing them his stock of furniture, in the hope of making a sale. He said, "This is solid walnut, and that is solid walnut, and this is solid walnut," and the old gentleman did not seem to be very much impressed by it. The furniture man seemed somewhat surprised, but was overwhelmed when the visitor said: "Look here, young man, by God, I come from a country where folks make fence rails out of walnut."

You can not make fence rails out of walnut now, but I have knowledge of a telephone line where some of the telephone poles are made of black walnut. Some day some man will come along and buy up that telephone line, but he will not do it because of the money he will make off of the wires, but because of the value of those poles.

I have simply risen to tell you that the governor of Virginia has appointed a State conservation commission and to say that he bids me express to you the fact that this conference can rely upon him to do whatever is within the power of the State—and I think there is great power in the State. As a member of the general assembly of Virginia, I think there is great power in the State for good along the lines for which our distinguished chairman has so well, to use a forestry term, blazed the way.

MR. WILLIAM E. MULLEN, OF WYOMING.

The CHAIRMAN. I take pleasure now, gentlemen, in introducing to you a representative of the governor of Wyoming, Mr. Mullen.

Mr. MULLEN. Mr. Chairman, ladies, and gentlemen, I appear at this meeting as one of the younger States, or rather as a representative of the governor of one of the younger States. I do not know whether our governor was one of those who, having attended the White House meeting last May, concluded that it would not be a desirable place for future residence. At any rate, he has asked me to appear here and represent him as best I can.

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The more I hear of this question of conservation the more deeply I am impressed with the magnitude of the question. Therefore, I do not believe that it would be profitable for me to indulge in a discussion of the local question as applied to our State. Better perhaps to discuss the question in its larger aspects. But there is a thought that I desire to bring before you now, and that is the application of a national policy of conservation in its relation to the settlement and development of the newer States. We have heard a great deal about the older States. Some of them have been held up before us as horrible examples of waste and destruction of natural resources. We of the new States, with undeveloped resources, indulge in the hope that we have a brilliant future before us, and are not in the position of the man described by one of our humorists as a person having a brilliant future behind him. It is perhaps to the advantage of the new States that the idea of conservation has been suggested before they have fallen into the errors of some of the older States in the waste and destruction of nature's bounty.

If you will bear with me for a moment, I will call your attention to a map. This is a map of our State. The green space indicates forest reserves territory; the blue space represents coal lands classified and withdrawn; the yellow represents Indian reservations; the upper corner here represents the Yellowstone National Park; the space in red along the streams represents land withdrawn for purposes of reclamation under government irrigation works.

In the first place we who now reside out there do not assert a claim to all of the unoccupied territory in Wyoming. We have in the State approximately 125,000 people at this time. We have a vast public domain that belongs to the people. It belongs to all of the people of the United States, and we hope that many of them will come to reside in our State in the near future. What I have to say, therefore, refers to the conservation question in such a way that I hope it will appeal to all of you.

The most important thing to insure the success of the conservation movement is, in my judgment, that of state cooperation in the classification of natural resources. I say that for the reason that I have been reliably informed that at least 75 per cent of the territory indicated on this map in blue as coal lands have been classified tentatively by a hurried examination of the surface made by the Geological Survey. It is the opinion of practical mining men that fully that percentage is of no practical value for coal-mining purposes. The opinion may be erroneous, but it is as likely to be correct as any of the conclusions arrived at by a mere examination of the surface. It is not actually known what per cent of this area is valuable for coal-mining purposes, and it will not be known until the lands have been explored by prospecting beneath the surface. And while there may be uncertainty as to the value of these lands for grazing and agricultural purposes under what is known as, in the West, dry-farming methods, and which may be carried on wherever the mean annual rainfall equals 16 inches, many persons have filed claims and settled in this region. Therefore I would suggest, in connection with this question, the great advantage of having local people, who are familiar with the conditions there, who understand soil conditions, and know something of the value of coal deposits commercially, to assist in the classification of coal lands, to the end that the greatest good for the greatest number may be accomplished, as I understand that to be the ultimate aim of the conservation idea.

There is no reason why this great territory should be withheld for coal mining if it be in fact more valuable for purposes of home making. The same is true to some extent in the case of the forest reservations. About one-ninth of our state territory is within national forest reserves. It is nearly all comprised of mountain lands situated at an altitude of from four to ten thousand feet, and much of it is really not valuable for forest culture for the reason that it contains a growth of lodge-pole pine, willow brush, and grass. Forested areas exist in the upper regions, but forest growth is exceedingly slow in high altitudes for the reason that the growing season is short, and it is said to be a fact that trees grown under such conditions produce a grade of lumber much inferior to that grown in lower altitudes.

Then, as to the real and effective work to be carried on for the preservation of timber, I fully corroborate what has been said by Senator Smoot on the general question of waste by fire. While it is true that a considerable percentage of waste occurs around sawmills and that the breaking of log booms on streams results in much loss where logs pass from control and find their way to the sea, the destruction by forest fires far exceeds any of these, and the loss from forest fires has been appalling. I believe that in our State a careful examination will show that where 1 acre of timber has been depleted by cutting for useful purposes, there have been at least 20 acres swept away and destroyed by fire. Long before the creation of forest reserves at all, vast areas of splendid timber were so destroyed, and it presents a sorry spectacle to witness hundreds of acres covered by dead timber strewn in every direction. Careless campers, travelers, and others, passing through the forests, leave smoldering campfires behind them, which are fanned into flame by the winds, and great forest fires result. Too much emphasis can not be placed upon the necessity of a vigilant fire patrol. More can be accomplished by preventative measures than by organizing to fight fires once started. It is a matter that ought to receive careful consideration.

It is the intention of the governor of our State to urge the passage of a law creating a state conservation commission, with full authority to cooperate with the federal authorities on all questions relating to the conservation, care, and administration of our natural resources. It is our belief that many of the errors which have occurred in our forest administration are the result of misunderstandings and errors of judgment on the part of the ranger, whose duty it is to deal with conditions at first hand.

Therefore, Mr. Chairman, it is a pleasure to give assurance to you of our intention to inaugurate at a very early date a state policy of cooperation which we hope and believe will operate to the mutual advantage of all.

I thank you, gentlemen.

The CHAIRMAN. Gentlemen, I want to emphasize just as strongly as I can what Mr. Mullen has just said about the necessity for cooperation between government organizations, state organizations, and individuals in all matters relating to lands or any other resources, forests, waters, minerals, or anything else. One of the essential things this conference ought to bring out is the absolute necessity of our stopping each playing alone in his own yard and getting together in one yard.

It gives me great pleasure to announce at this time that we have with us a representative of one of our neighboring governments, Senator Edwards, of Canada, whom I now present to you for an address.

SENATOR WILLIAM C. EDWARDS, OF CANADA.

Senator EDWARDS. Mr. Chairman, ladies, and gentlemen, this is the first time I have ever appeared before an audience of the great Republic of the United States, and it gives me great pleasure, I assure you, to do so on a subject which is very near and dear to me, that of the conservation of our natural resources.

I am here at the instance of the government of Canada, a government having the kindliest feelings of regard for everything which means the promotion of the good of the great United States.

Before leaving Canada I asked his excellency, the governor-general, "Have you anything to suggest to me about what I shall say or to which I shall particularly refer?" He said, "No, further than to join with that great and progressive man, Mr. Pinchot, in promoting the object which he has in view in this gathering."

Before I overlook it, in the short time I have to address you, I wish to mention now that I also asked our prime minister if he had anything special to mention. "No," he said; "I think you are full of the subject upon which you are going, but there is just one thing on which it would give me great pleasure, if the congress which is to meet in Washington on the conservation of natural resources would pass a resolution suggesting that the Government make most stringent laws with regard to railways in their prevention of fires, for in my opinion they are great disseminators of forest fires." His reason for making that suggestion is that if it should come authoritatively from this source he would have it in his hand as a lever to enable him to pass a similar law in Canada.

I wish before proceeding to congratulate, in the most hearty terms, your President and your worthy chairman for what they are doing in this respect, in the promotion of the conservation of the resources of your great country. I have heard, during the speeches and presentation of the many addresses here, matters which interested me intensely. I am greatly repaid for coming here, if to have heard nothing at all but the presentation of the first report and inventory of your natural resources, and I would have gone many, many miles to have heard it and many miles to have heard many of the other speeches, particularly the one from the gentleman from Colorado [Mr. Richards].

The question this morning is that of the conservation of your forest resources. Like ourselves in Canada, you have been prodigal with your resources. You have unduly destroyed that great resource, and so have we. A speaker a short time ago said, however, that twenty times as much had been destroyed by forest fires as ever was destroyed by the lumberman's ax. I subscribe to that. That is my opinion. Therefore, the greatest means of preventing that great destruction is the prevention of forest fires.

What is the meaning of preserving our forest resources? Not only the conservation of that very useful product for the people, but also the conservation of our waters for power and the many other purposes to which water may be applied. In Canada we are devoting ourselves to-day to the same objects to which you are devoting yourselves, aided and promoted very largely by our friend the chairman, who occasionally visits us in Canada on this very important subject.

We have heard something of your inventory in other resources, as well as those of lumber. Your country of course is a very large one and your resources in respect of lumber have been greater than ours, but to-day we are supposed still to have 535,000,000 acres of forest lands. Out of this quantity of forest lands, the government has set aside, as forest reserves, 121,000,000 acres. I do not know how that compares with yours, but I will say this: Thanks to forestry, thanks to the initiative which has taken place with regard to the conservation of our resources in that respect, if Canada takes the lessons that it should take from such gatherings as this, and even at this late day awakens to the necessity of conservation and promotion of forestry, Canada, in so far as her own needs are concerned, need never want for a supply of timber. I am not of the opinion that Canada can be a large exporting country for many years to come, but it will be a great thing for Canada if she is able to conserve lumber for her own needs. Let us hope that the great American Republic will do the same thing, and I believe it will do so, if regard is paid to the lessons which are here taught, if the country becomes imbued, as I hope it will, with this great necessity; and if this comes about, I think possibly the United States also need never want for a lumber supply.

In listening to the speeches that have taken place here, two things have very forcibly been impressed upon my mind. I never thought before of the important part water may take in the conservation of your coal supply and in the conservation of our coal supply. Our coal supply and your coal supply may become exhausted. Your iron and our iron may in many years become exhausted—however, we also have a great supply of those two articles—but our water supply, if we preserve the headlands in our forests, never will become exhausted. We are doing exactly what you suggest; we are beginning to impound our headwaters to conserve our water supply. If you do what you can do in that respect, look at the great possibilities that there are of to-day beginning to conserve your coal, which is a disappearing quantity.

Another thing which impressed me was what are we going to do when our iron supply becomes exhausted? I was a little surprised to hear that in the middle of the present century iron, as used to-day, of the quality used to-day, will become exhausted. To my mind there is one article that can be considered in the way of conservation of iron ore to a very great extent, and that is the use of cement. I am a lumberman, and a lumberman on somewhat of a large scale. I do not build one single structure to-day of lumber. Every structure that I build is of concrete and steel—largely of concrete. I built a large mill of concrete this very summer, and built a very large factory establishment also, all of concrete. It sounds strange for a lumberman to advocate anything of the kind, but I am one of these lumbermen who believes strongly in the conservation of our forests.

Just before I part from you there is one thing I desire to say to you. Canada has the advantage—and I am surprised to be in position to tell you so, and you will be surprised to hear it, many of you—Canada has the advantage of having secured a large portion of her lumber supply this year from the United States. I am a lumberman, and it sounds strange to come from me, but I want you to send it on. Keep sending it to us. Our timber will grow in the meantime, and we will profit later on.

Gentlemen, I thank you very much for your attention.

MR. FRANK H. LATHROP, OF ALABAMA.

The CHAIRMAN. I will now recognize Mr. Lathrop, of Alabama, for a short address.

Mr. LATHROP. I am living in Alabama, but was reared in Michigan. My mother was a Canadian, and I can appreciate the remarks of the gentleman who preceded me. I come here, ladies and gentlemen, representing the governor of Alabama in forestry, not in politics, because our politics differ. I do not want to be misunderstood on that question.

On September 23, 1908, in the midst of the presidential campaign, I was notified by the governor of Alabama that I had been appointed one of a committee of five to gather statistics and help compile an inventory of the natural resources of the State of Alabama, in line with and in compliance with a unanimous agreement of a conference of governors of the several States made in Washington, D. C., in May preceding of this year.

After November 3, and as soon as I could get my business matters in line after more than two months of inattention, I became convinced that the subject assigned to me, namely, the timber resources of thirty-five north Alabama counties, would be a Herculean task to form a correct estimate of, in a most crude manner, to say nothing of taking a correct inventory of same, to use the words of our correct and business-like governor, who prides himself on his knowledge of business details as well as the name and residence of every new married couple living on the hills of north Alabama, in whose homes and families his face and name are as familiar at this time as is the family Bible, or more so.

Now as to the inventory, or more commonly called "estimate of timber," to use a lumberman's phrase. I find on consulting the highest authority, such as the editor of the recent Lumber or Timber History of the United States, and some of our largest timber or lumber manufacturers, that the heretofore basis of inventories on this asset of the Commonwealth of Alabama is entirely at fault as to the present status of the case. And to sum up the matter, and at the same time sound the warning that has already been voiced by our national forester, Gifford Pinchot, I am compelled to indorse his statement that our forests are not only being denuded at a rapid rate, but also that I do not find over 10 per cent of the original forest now standing in north Alabama. And while more than three-fourths of the territory above described contains a good growth of wood and timber, much of which is what is termed "immature," trees that would become mature in a period of from ten to twenty-five years, if the present condition of said forests could be conserved and protected from the wholesale cutting and denuding process now in vogue by the owners of said lands and timber rights. Also, said timber in various stages of maturity could be made a continuous source of income and profit if a system of cutting the same could be inaugurated similar to the methods of forestry now being protected in the older countries of Europe and in Germany, namely, the methods of marking and cutting trees only that have attained a certain size, and the caring for the children of trees that are immature and under size and age. It would seem that this plan should appeal not only to the general public but also to the owners, when it is demonstrated that the natural growth of small timber trees is greatly accelerated by the thinning-out process, and at the present time, under favorable conditions, amounts to more than $1 per acre per year on reasonably well-wooded land.

I submit herewith my deductions of the entire acreage of 35 counties in north Alabama and the entire amount of commercial timber acreage. Possibly one-third of said timber of acreage showing wood will be cleared and put in cultivation or pasturage during the next six to ten years. The balance, or one-half the lands in said territory, is unfit for cultivation, and can be treated by forestry methods if the denuding methods now going on at a rapid rate should be changed to a more reasonable system of cutting with a view to preserving the future forest area of the State, and the maintaining of a constant and maximum amount of matured annual growth of timber that will command the highest values in lumber and by-products, such as wood for fuel and farm purposes taken from the timber cut and utilized to its fullest extent.

I have submitted to the chairman certain estimates made after my twenty years of observation and operations in manufacturing the timber of north Alabama, which are, in my judgment, not underestimated as to the amount of standing timber that, in its entirety on all the territory, will make lumber of all the forty or more grades and sizes, while the manipulations of grades and sizes of lumber can be added to by using the small trees. As a rule, the matter of cutting small trees is simply a matter of turning a day's value of work into a dollar without profit, hence is termed in lumber terms, "simply a bread and no butter business." That should be a strong appeal to a more liberal and philanthropic method of treating one of the main, if not the main, assets for conservation, of one of the main resources of the State, keeping ever in mind the great fact that the life of the State and nation depends absolutely on our material resources and the conservation of said resources.

MR. ANDREW CARNEGIE.

The CHAIRMAN. Among our distinguished guests to-day is one whom we all know, and from whom we shall be glad to hear. I refer to Mr. Andrew Carnegie, whom I now take pleasure in introducing to you.

Mr. CARNEGIE. Mr. Chairman and gentlemen, circumstances over which I had no control have prevented me from being with you before. I want to tell you how enthused, how elevated, how delighted, how instructed I have been by this meeting. I have not enjoyed a morning like this at a meeting for a long time, and I will tell you why.

The great obstacle to the reforms for which we work to-day, the conservation of our resources, lies in a federal system of government, the General Government. None of us would part with that. The relation of the Federal Government to that of the States is a matter of decided importance, of course. That relation should continue. We must have it. The great obstacle to-day, as you see, is to get the States and the nation to work together. That is the one obstacle we must overcome. I told the waterways commission a story to show how rapidly we are advancing and sinking—not obliterating the State into the nation. We are all members of one or other of the States, Pennsylvania, Alabama, South Carolina, Virginia, Minnesota, or another. But we are something higher and wider. We are all Americans! Let us remember that.

I asked Mr. Blaine once, "What is the most effective speech you ever heard in Congress?" "I will tell you," he said. "It was the first time that it was proposed to appropriate national money for fresh-water improvements, and the House became excited and angry. Governor Ritter, of Pennsylvania, had been elected a Member of Congress. He had never spoken before, but to the astonishment of the Speaker the old gentleman arose. The House hushed in a moment. Every one wondered "What is coming?" Governor Ritter said:

> Mr. Speaker, I do not know nothin particulars about the Constitution, but I know this: I would not give a cent for a Constitution that would not wash just as well in fresh water as it did in salt water.

The House did what you did, gentlemen. It burst into one storm of applause, and that bill was passed, and that is the foundation of our whole fresh-water improvement today. Go on in that direction. Let us go further and further and all will be well.

I wish to say something to the gentleman from Canada. I am a broad American. No lines confine me in that respect. The city of Winnipeg has a library I gave. They founded a historical society, and the first honorary member was your humble servant. I wrote them telling how delighted I was, first, because they were Scotch, and, second, they were our great neighbors; and they were going to record their history as they made it—they were up to date. Then I said that I always felt that Canada occupied with reference to the United States the proud position that Scotland occupied with regard to her southern neighbor, England. Scotland, through its King, annexed England and has ruled it ever since for England's good.

Now, that is the destiny that I predict for North America. Canada will play the part of Scotland; she will annex her southern neighbor and do it incalculable good in giving us more of the strain of that invaluable element which has made North Carolina and South Carolina and not a few other lands so great, the Scotch.

Gentlemen, that is all I wish to say to you, but remember one thing—and it is an audience like this that should hear it—you are loyal people of your States, but thank God for this, that even above your love for your State you have the greatest empire that ever the sun shone upon and you are progressing splendidly, marching forward rapidly. You people here, you ardent reformers, and you, my dear friend, Mr. Pinchot, think we are not marching fast enough. We are driving pretty fast, gentlemen; we are driving well, and there is no limit to what this great continent is to be in the future. Good morning.

The CHAIRMAN. I have one other request to make of the gentlemen who have asked for recognition. I see that Governor Pardee, of California, has come in, and I know as governor he ought to have the right of way, even though he is not the actual governor for the moment. I am sure we shall be glad to hear him.

EX-GOVERNOR GEORGE C. PARDEE, OF CALIFORNIA.

Mr. Chairman and gentlemen, I hope you will all agree with me when I say that three Presidents of the United States stand out head and shoulders above their great fellows: Washington, who created this great nation; Lincoln, who saved it; and Roosevelt, who has done so much to perpetuate the comfort, the progress, and the prosperity of our people and the very perpetuity of the nation itself.

A nation such as ours, with all the great resources that have been and still are ours, can not help but be great. But if these resources be wasted this nation, like others that have gone before it, must crumble and fall into dust. You will remember that in the days of Him who was crucified the Holy Land was a densely populated country. Those of you who have traveled in it in these later days have seen how barren and droughty it is. In the old days its mountains and its hills were covered with forests. Those forests have disappeared and the land, barren and dry, supports only a scattering population of shepherds and nomads.

China in its day was densely forested in its mountainous regions. Every tree of those forests has disappeared. The rivers of China run riot, destroy thousands of human lives every year, and the land is arid because the people of that country have destroyed their forests.

A portion of Spain in the olden days was densely populated by a prosperous agricultural people. They cut from the hills the forests, and those valleys, once fertile and supporting a dense population, are now droughty, arid, and torn by the floods of winter and spring.

Portions of our country have suffered the same fate, and it lies in your hands, gentlemen of the States, it lies in your hands to cooperate with the National Government in order that those forests may be saved and the future prosperity of our children and our children's children may be preserved, in order that the nation may continue to be one of the great, if not the greatest, nations on the face of the earth.

We put on the uniform; we shoulder the musket; we follow the flag in times of war and do not hesitate to suffer and die for the benefit of our country. There are greater problems and crises than those of war. They are the crises and the problems of peace. One of those crises now confronts this country, as we of the West know better, perhaps, than you of the East and South. That crisis is of the greatest importance for the present and the future. It has to do with the salvation of the country through the salvation of its forests, and the salvation of those other great natural resources which have made and are making now, and will, if we save them, continue to make us great.

And that, as has been so well said here upon this floor, can only be done when the people of the States remember that, while the States are great, the American Republic is greater than them all—greater because the States could not exist free and independent without the nation.

MR. POWELL EVANS, MEMBER OF THE PENNSYLVANIA STATE CONSERVATION COMMISSION AND REPRESENTATIVE OF THE AMERICAN AUTOMOBILE ASSOCIATION.

Mr. EVANS. Mr. Chairman, speaking as an appointee of Governor Stuart, who could not possibly be here, it is the feeling of our state commission that we should like to return with more instruction as to the practical things for us to do as the commission of the State of Pennsylvania.

I called attention to this matter this morning in a resolution which was submitted to one of the members of the committee on resolutions, and he suggested that it be presented here now.

We understand, especially those who were here last May, as I was fortunate enough to be, the necessity of coordination in state work through this National Conservation Commission, but we are somewhat at a loss, as a state commission for the State of Pennsylvania, as to the practical form this effort is to take.

Our thought is that if we had a schedule of the necessities that each State now knows it has within its borders in line with this general movement; of the points at which national bodies asked here as conferees touch with this general movement; of the particulars of the conclusions of the commission itself, it would give us a bird's-eye view of the great conservation movement in its entirety for the United States, from which we could pick out the proper work to be done within our own borders.

Is it in order to read this resolution?

The CHAIRMAN. I am afraid that the chair will be obliged to rule, in accordance with the expressed will of the conference, that all resolutions must be referred to the committee on resolutions without debate. I am sorry that that must be my ruling, but I have been so instructed.

Mr. EVANS. I am sorry. I want to say one word here on a matter which is at present of importance in the State of Pennsylvania and to the American Automobile Association, and that is on the subject of good roads.

As I understand it, good roads are now supported in a measure by forest revenue in some States. The State of Pennsylvania is behind in that movement. I do not want to be considered as pleading for a special interest here in behalf of the American Automobile Association. Its work in this direction is in entire accord with the National Grange, a national organization comprising a million farmer members all over the United States. It is working in accord with the Good Roads Association, another body of private citizens.

We have in this country only about 8 per cent of our road systems that are improved comparably with any one of the western European countries.

It is proposed in our State, we hope in ten years, to spend something like $50,000,000 on that work.

The State of New York is now spending $5,000,000 a year—$50,000,000 totally.

The State of New Jersey has been doing the same work.

A convention of six governors and their advisers, in New England, recently met largely to consider this question. The difficulty is that unless the movement is coordinated through some such agency as this the money is not properly spent when it is provided. There is not a uniform knowledge of how to build good roads in principle. The practice must vary with the minerals and with the character of the soil. There is no uniform legislation regarding road use. It is the feeling of this body which I represent that it is strictly within equitable and constitutional limits that interstate travel over highways should be governed by interstate laws, and not by a different law in every one of the 45 States.

A farmer of the borough of Sewickley, in the State of Pennsylvania, once told me that he "did not object to using four horses to pull a load of milk up the hillside in winter, but it was going too far to use four horses to pull the load down the hill." That is the condition of much of the highway all over the United States.

I hope to see this commission come in touch with the practical necessities of the people in many phases of economic work and thrift like the above, which do not lie strictly within the borders of the great subjects of mining and forest preservation, however important they may be.

I thank you.

COMMISSIONER JAMES S. WHIPPLE, OF THE STATE OF NEW YORK.

Mr. Whipple. Mr. Chairman, ladies, and gentlemen, I am so very much interested in the preservation of the forests of the country that I am not willing that even roads shall interfere with it.

I am very much in doubt whether a plain, practical man ought to take much of the time of a convention like this where there seem to be so many scientific men; but to me it has always seemed that what we call in western New York "common horse sense" is so much better in working out a difficult problem than, sometimes, technical knowledge alone is, that perhaps you can stand for a little just now.

Forestry in this country is very young—practical forestry.

I have listened here for two days, and I listened last spring at the other conference for two days, to splendid things said and great thoughts propounded; but very few men have suggested remedies that seem to me we could apply and do something.

The paper on forestry read this morning is a fine report, but I have to say, Senator Smoot, that you left out the one great, important thing, and I hope you will pardon me for saying it——

Senator Smoot. Certainly.

Mr. Whipple. You have not said a word about how to reproduce forests, practically.

Now, it is all nonsense to talk about our having forests enough by natural reproduction, and you all admit it. You may say that we are cutting off our forests, some of you say this, three and a half times faster than nature produces them. If that is true, that is the whole proposition, is it not? How long is it going to be before you have no forests, however carefully you handle them?

The gentleman from Alabama thinks that they have forests enough, if practically handled, to take care of the interests down there for some time; but do you not know that we are cutting 40,000,000,000 feet, board measure, each year out of the United States forests, and that 1,500,000,000 feet of that are taken out of my own State's forests? If you will look at the charts you will see that that is a small part of it when we consider the loss by fire and insects, yet that is more than three and one-half times the growth. If you admit that fire is sweeping away more than you cut, and one-third of what you cut is loss, and your population is increasing so fast that in fifty years you will have 200,000,000 people in America, and the demand for timber is increasing faster than your population, and the supply is decreasing much faster than either, what are you coming to in America? The questions I am asking are, what are you going to do about it? How are you going to prevent it? What are your remedies? No one has told us.

You are using 2,000,000,000 feet, board measure, for newspapers alone.

In the State of New York there is standing to-day only about 41,000,000,000 feet of saw timber. We are cutting it five times as fast as it is produced. The State owns 1,600,000 acres of that timber land that must be deducted from the calculation because of our constitutional provision. What is our situation? In twenty years, at the rate we are going, not one sawing stick will stand in the State of New York; and we are getting 85 per cent of our pulp wood from Canada, even if our good friend does insist that some lumber goes back to Canada.

What is the remedy? That is the question. We can not take it out in resolutions and talk; we will have to do something.

We have got to get out, every mother's son of us that has an acre of land that is not good for agricultural purposes, and plant trees. It won't do to set it aside to the National Government and the States as forest reserves alone; we must economize in every way possible; but, above all, we must plant trees.

Germany has planted trees for a thousand years, and all of its forest is a planted forest. The German people produce 100,000 feet, board measure, all told, upon a single acre. The best timber in this country, east and south and west, until you get to the great trees of the far West, will not run over 20,000 feet to the acre. We have got to be practical; we have got to use this common horse sense. What ought you governors to do? Allow me to speak just as plainly as I can, in the western New York way. Go home and establish a commission, if you have not done it already, and put a Pinchot at the head of it.

Then furnish it money, and don't get down on your knees, or anywhere else, and implore the National Government to set aside some state land in a national forest; do it yourselves. You may kneel at this shrine for years and you won't get it done. The way to do it is to do it yourselves. It is in your own hands.

Get a little state forest preserve, and then handle it in a practical way. Don't do it as we are obliged to do under the constitution of the State of New York; that is, let it stand there and rot and burn up, and we not able to take out a single stick. We will have to amend our constitution.

Be practical about it! Then build some tree gardens and put your last dollar into it, that you can raise. Plant every year some millions of pine trees. Hard woods reseed themselves; they come up from the sprouts; but the coniferæ in this country must be planted, as every practical man knows. You sweep away a pine, spruce, or a hemlock forest and it will never grow again; those trees must be planted. In Canada and some other places they do reforest pretty well, but not in our country. Be practical. Don't do so much wishing and resolving, but do business.

The next thing you want to do is to go among your people; go out as missionaries among the people. Do not get it into your heads that all of our people, not even our legislators, know about this business, for they don't know about it. None of us have known much about it except for a few years.

Just think! In 1885, in the State of New York, the first commission in the United States was organized. At that time not one single educated forester lived in the United States that anyone knew about; not one forestry school existed at any college of the United States. Twenty-three years! It took us twenty years to do the preliminary work, and it is only within the last three years that we have aroused the whole people in the State of New York. How did we do it? We got out among them at their homes and made speeches; told them of this wonderful cut of timber and the great amount it was over the natural reproduction. We told them of the history of China and of France and of the other countries where their timber has been swept from the hillsides and the land denuded and made worthless for agricultural purposes, as the governor from California told us a moment ago.

The **Chairman**. You have two minutes more remaining.

Mr. **Whipple**. I wish I had thirty minutes more, to get some practical things into the heads of the members of the congress. You can not have a country worth living in without forests, and the proof of it is the history of the whole world. You cannot have your water running in even flow from the uplands without forests.

You are talking about conserving forests. New York City is spending $150,000,000 to build a reservoir at Kingston to get water for the 4,000,000 people in the city of New York. If New York City does not protect the trees upon those historic hills, the Catskills, that reservoir will not do all that is expected of it, and they will have to go somewhere else for part of their water supply. Why? Because when you destroy God's reservoir under the trees man can never build one as good. It takes that natural reservoir to keep and hold the water, and you can only maintain that on the hillsides by keeping the trees there. Therefore their money will be spent in vain unless the trees are kept there.

Some one in the report of this commission has said that there is as much water as there ever has been, and that we could not create water. Those men that drew the original report of this national commission are mistaken. You let a spring dry up on a mountain side because you have taken the trees away. That water is gone. It has disappeared from thousands of our springs to-day. But you reforest that hillside and you will reproduce the water. Those springs dry out because the forests are gone, but you reforest the hillsides and the water will come back. There is too much to the subject for any man to undertake to cover it in ten minutes.

A **Delegate**. I move that the gentleman's time be extended by unanimous consent.

(The motion was numerously seconded.)

The CHAIRMAN. Is the request that the gentleman's time be extended ten minutes?

A DELEGATE. Yes.

The CHAIRMAN. Is there objection to extending Mr. Whipple's time for ten minutes?

(There was no objection, and it was so ordered.)

Mr. WHIPPLE. We have to have forests in the country, ladies and gentlemen, because of a hundred things. First, they affect the climate, they affect the rainfall, they are valuable to the agricultural lands. Without forests in a rolling State like New York or like Pennsylvania you can not have producing agricultural land. Am I not right?

A VOICE. Right!

Mr. WHIPPLE. If water is not absolutely necessary to good farm lands, tell me why it is that the arid lands of the West do not produce without it. Tell me why it is when you pour a little water on the arid lands of the West, where stump cactus grew, and that only, you can produce 50 bushels of wheat to the acre. Tell me why it is that the far-famed, beautiful valley of the Euphrates, which we have heard so much about in song and story, once as beautiful as a dream because of its forests and streams, is to-day a howling waste. Simply because the forest trees were cut away and the waters dried up. We must have water. We must have the forests in order to have the water.

Kansas, Ohio, Indiana, or any level State, do not need the forest trees for agricultural purposes so much as we do in New York and Pennsylvania and the East. Why? Stop and think. In New York State all but four of the great rivers of the State head in the Adirondacks and Catskills—in that 2,000 feet elevation, upland plateau. The streams, when not protected, run rapidly away and the water is wasted. It does not even have a chance to evaporate. But on the level plains of Kansas it falls upon that flat land and it soaks into the ground, it saturates the soil, it produces moisture necessary, for weeks and for months, for the crops to grow upon the land. We must have the forests. You can get along out there if you don't have so much forest.

So it is rather a local question in respect to the farm lands of the country. We have got to have forests because of the healthfulness of a country. Do you not know that the forest trees are constantly pouring off into the air great quantities of oxygen; that they take up the things that are poisonous to your life and grow upon it; and that they furnish that which we must have? Do you not know that they have a wonderful effect upon the temperature of the country? Can anyone tell me why it is 25 degrees cooler in July at Lake Placid or Saranac than where I live in the Alleghenies, in the same altitude, 200 miles farther south? Nothing in the world except that splendid great forest that covers that upland in the northern part of the State of New York.

Let me make it perfectly clear to you by the simplest illustration. If forests are not as valuable to a country as I say, what would be the condition if to-day, through some great force in nature, every tree and shrub should be swept from the face of Pennsylvania or New

York State? Would not chaos reign to-morrow? Would not the home of every wild bird and every wild animal be destroyed; would not every stream be uncovered; would not the surface of the land be like the roof of this building for the water to fall on it and run immediately to the stream and down to the great sea and be lost forever? Would not the price of agricultural land in those two States depreciate in fifty minutes 50 per cent? If it would not, then the history of China is a lie; then the history of France is false. Three hundred years ago France swept its forests from its hillsides; its land was eroded and washed into its harbors. If it is not so, then France has spent $200,000,000 since then to reforest those mountain sides for nothing.

The country that does not have forest growth is like a house without a roof, uninhabitable and worthless to the people.

You may talk about preparing your Mississippi for transportation of the products of the country. You may talk about the conservation of your coal and iron and gas and oil, and all that. Coal, iron, gas, oil, and other minerals are only created once in the creation of the world, and all you can do is to handle them as carefully and as economically as you can; you can not replace a pound of them. But your forests, the great objective point, it seems to me, may be restored, must be saved, and you can only save them by careful handling and by planting.

Now, go home, get your commissions to furnish the money. Build your tree gardens. Go among the people and encourage them to plant trees and relieve their land that is dedicated to forests from taxation. Encourage your people. Give them the trees free. Let the State furnish its people with the trees free of charge, in order to encourage them, and then relieve them from taxation on the land dedicated to the forests, and you will get every farmer raising trees.

Think of what New York is doing. The pioneer in the work, twenty-three years old, held up sometimes as an example. We are doing a lot of things that we do not ask the National Government to help us in. We know we would not get its help. We are going to take care of it ourselves. We are spending $500,000 $600,000, $700,000, $800,000, $1,000,000 a year in buying land, and we are going to keep it up.

But get your farmers to planting. We are building tree gardens all over the State, raising millions and millions of pine trees. We don't plant the poor kinds of trees. We get the best commercial tree, that grows the fastest. The hardwoods will take care of themselves if we let them alone and keep the cattle out. Plant pine trees, plant spruce trees, plant in the South the tree that grows the best there and is the best commercial tree. But all of you have got to plant trees.

As I have said, our State is the pioneer in this, yet we are asleep in America on this question. We have to get practical and get down to business and plant trees or in twenty years our children will curse us for our negligence.

GOVERNOR JOHN A. JOHNSON, OF MINNESOTA.

Governor Johnson. Mr. President, I simply want to rise to ask a question. I think I probably grew as enthusiastic listening to the remarks of the gentleman who has just spoken as any other person in the room, and I was impelled to applaud probably as rapidly and as frequently as any other man here, and it is a nice thing to sit here and be told that you don't understand this question and we want to give you the practical results. Now to my mind I want to ask the gentleman what is the remedy? After all—I may have been obtuse myself, and there may not have been any ambiguity in the remarks made—but what is the remedy? Plant trees! I heard that in May last year when we had that conference, until I got black in the face. I have heard it in my country for ten years. And this thing of going back home and planting trees is all right; we have got to plant the trees. But the governor does not own the farms of the people of the State of Minnesota, and the governor of North Carolina does not own the farms of the people there, and it is the same way in every other State. The governor does not own the great lumber areas that have come into the care and watchfulness of the great lumber barons of the country, and he can not plant trees on that land, and he can not go home and make the legislature do anything he wants them to do with the public moneys of the State, because the legislature in the State is the custodian of the public moneys of the State, and that is so in every State in the Union. So it won't do to say you do not need the interest of the National Government, and the gentleman who has just spoken confesses at the conclusion of his remarks that he is going to plant two or three million trees a year, and he says that they are cutting down more Christmas trees in the State of New York than they are planting each year.

We do want these discussions, we do want all the information we can get, and I was very glad that the last speaker spoke of the matter of exemption from taxation as an encouragement to the planting of trees. It is about the only reasonable suggestion I have heard here.

With regard to the matter of forestry, without desiring to introduce his name, I think there was suggested at the White House at the conference there in May the best suggestion in the way of forestry that was made there or here. Unfortunately it introduces a political question. Are we going to avail ourselves of the vast areas of Canada by reciprocal trade relations, or are we going to continue that barrier in the way of an imaginary line, which will not permit us to bring in the Canadian lumber as a means of protecting our own lumber?

I know full well that there are men here attending this conference who are personally interested in the manufacture of lumber in America who are going to do all they can to make this country refuse to take any action looking toward the bringing together of the great Canadian and great American interests, and I hope the conference will be big enough to look over the heads of any men who have a personal interest. What will take the place of lumber? I have formed a great affection and regard for the gentleman who some time lived at Skibo, if that is the proper pronunciation, because I believe that in the introduction of steel he has done more to preserve the forests than any other individual in this country.

We have got to go home and talk to our people, and I am going back to talk to mine. Appoint a commission? That is good. We have got conservation commissions in the national way. This, in a sense, is a commission. Let it go back and reforest America—this handful of people. This discussion is good in the matter of education. No one in my State thought of it ten years ago. No one in my State thought of the enlargement of the Mississippi River ten years ago. No one in my State thought of the erection or construction of canals through the central basin ten years ago. But it is because of the pioneers, if you please, who blaze the trails of public opinion, that all these things are made possible.

I would be glad to have a specific and definite remedy. In my judgment we have got to retrace much of the ground we have already lost. I know something about governmental reforestation in my country. I know something about the preserves where 10 per cent of the trees must remain. In my judgment, Mr. Pinchot, that is absolutely a failure, because the 10 per cent, lacking the protection of the surrounding trees, either dies, breaks down, or eventually gives way.

It seems to me it would be better to preserve great tracts of trees. But there is so little that any of us know—even, I think, the expert from the State of New York, who failed to give us a specific remedy for the reforestation of the country—that we all ought to be willing to learn, and I would like to be able to take home one great big idea and say to the legislature, "Do that." And if the gentleman from New York will give me the opportunity to do it, I will be his servant forever.

Mr. WHIPPLE. A question has been asked. There are so many ideas to give that it is hard to sort out the ones that we can advance and have take effect in so short a time. Let me give the gentleman an idea.

We believe, in the State of New York, and we are going to put it in operation this year, that the State has the power to control the cutting of timber on private land; that is, to prevent denudation, also the clearing up of the débris, and so on. We are going to put that into the statute.

Mr. JOHNSON. I would like to ask whether that is a fact—that the State of New York, or any other State, has the right?

Mr. WHIPPLE. The Supreme Court of the United States has said so, as cited by your President in the May conference. There has been a decision by the state supreme court of Maine to the same effect more recently.

Mr. JOHNSON. I may be wrong, but I did not think the Supreme Court had decided that—that is, the Supreme Court of the United States.

The CHAIRMAN. I think it was the supreme court of Maine.

Mr. WHIPPLE. But underlying constitutions, there is in the police power of the State the power to do that which will protect the whole people——

Mr. JOHNSON. I would like to know what is the actual fact about that decision. Mr. Pinchot says that he thinks that was the supreme court of Maine.

Senator SMOOT. I think the last point the gentleman has reference to was a decision by the Supreme Court of the United States, as I remember it. The decision of the supreme court of Maine was upon the other point.

Mr. **Whipple**. There was a question that went to the Supreme Court of the United States on the question of whether the State had the power to regulate the use of private property for public good. It was the case of the Hudson Power Company and arose in New Jersey, in order to protect the people in the lowlands in the matter of the water flowing over their lands, as a general public necessity. That was the case, if I remember the title correctly. There is also a case to the same effect in Massachusetts, where the court said to regulate was not taking.

The practical working out of it in our State. Mr. Johnson, is solved, I think, in this way. We got last year a great many farmers to plant trees. As I said, the State can never plant enough, because the cut is so great you can not keep up; but if you get every farmer to planting trees, and we are giving them trees now at cost and will next year give them absolutely free—if you will do that and then get your foresters to show them how to plant the trees and get every farmer on every farm to take an interest in this work you will be able to accomplish something. Our farmers are getting enthusiastic about it.

Mr. **Johnson**. You speak of getting the farmers to plant trees on their farms. In the States of Wisconsin, Michigan, and Minnesota there are millions and millions of acres of land that have been cut over, and they are not farms at all; it is not farm land, it is a sandy soil. What are you going to do as to that kind of land that is not farmed and will not be farmed for years to come?

Mr. **Whipple**. There is a lot of land in New York, too, that is poor land and has been worked out. It is sandy, poor land, and not good for farming. We think the State should acquire that land. We have a commission to buy land, which commission is always in session, and we are buying about a hundred thousand acres a year. We have 1,600,000 acres now, and we are going to buy 2,000,000 acres more and reforest it. That is what the State is doing. Some of the poor sand lands are only worth $1.50 to $2 an acre, land on the Upper Hudson and in the Adirondack country, but forests can be planted on that land, and forests are growing there now in the finest kind of way. And so with your State. Your State should acquire that land you speak of, in my judgment, and you can raise enough trees on it to support the needs of your State. That is what Germany has been doing. Many of its little villages have been planting trees, and from those trees they are able to pay their taxes and supply all the lumber they want. We must be able to do that if the Germans can do it.

Mr. **Johnson**. There are lots of things we do not know as much about as the Germans do.

Mr. **Whipple**. Well, we must get at it, then. If there is any other specific question——

The **Chairman**. May I ask your indulgence for one moment. There is one suggestion I want to make to Governor Johnson and all the other governors here and perhaps this is a good time to make it. It seems to me that if each State could do what Alabama and Oregon and a half dozen other States are doing, and take stock inside of their own properties, of their own resources, exactly as the national commission has been taking stock of the national resources, we should get a body of information that would be of the utmost value.

I believe that there is nothing more important for the States to do than to make a study of their own situation through their state conservation commissions.

Senator SMOOT. I simply want to say that I hope none of you will rely on being able to get lumber from Canada in order to save our own forests. I have been in Canada, through their forests, and I think if we ever put lumber on the free list, as suggested by the governor of Minnesota, with the idea of getting lumber from Canada——

Mr. JOHNSON. Excuse me. I did not use the term free list. I simply thought there might be some arrangement that might allow us to bring in our Christmas trees, anyhow, while the other trees were growing. Excuse me, I have to leave.

Senator SMOOT. If you will confine it to Christmas trees, all right, I will not have anything to say.

EX-GOVERNOR NEWTON C. BLANCHARD, OF LOUISIANA.

Governor BLANCHARD. Mr. Chairman, on the question that was raised by the gentleman from New York, as to what the power of the States may be in respect to controlling the cut of timber lands embraced in private holdings, I desire to say that that question has occupied the attention of the governors of some of the States, and perhaps all of them, for some years.

In my message to the general assembly of the State of Louisiana in 1906 I recommended the enactment of a law that would prevent the holders of large bodies of timber lands from cutting any trees under 10 inches in diameter. I urged that they be required to cull the trees, cutting only the larger ones, and leave growing the smaller ones, in order to perpetuate the forests.

Before putting that proposition up to the general assembly, I consulted eminent counsel as to whether or not there were constitutional difficulties in the way. When I presented it to counsel, he shook his head and said, "I fear there are such difficulties." I replied I thought not; that in the question was involved a great public policy, and wherever there was a sound public policy involved authority would be found to sustain legislation in aid of it.

The lawyer consulted was asked to examine the question, and in a few days he returned to me saying that my view was correct; that he had found authority to sustain the legislation I had recommended. I had him prepare a bill, which was introduced in the senate of the State, but it failed of passage. The timber lobby was too strong for it.

It will be remembered that when the governors were in conference with the President at the White House in May last, the President stated in his admirable address that the legislature of the State of Maine, having the right under a custom there obtaining, to ask the supreme court for an opinion upon a proposition as to the constitutionality of which they were in doubt, certified to the supreme court of Maine, the very question that we are now discussing, and that court returned an opinion that the authority was in the legislature to do the thing desired.

And in the discussions that took place at the White House upon the occasion of the conference it also appeared that the question was brought up in a New Jersey case that went to the Supreme Court of the United States, not upon this identical question, but one akin to it and involving the same legal principles, and the Supreme Court affirmed the power to be in the legislature to do that which had been done.

Mr. Chairman, another important question affecting the conservation of the forests is that discussed briefly in the report and alluded to in the speech of our distinguished friend, the Senator from Utah, this morning, and in other addresses. I refer to the policy of taxation looking to encouraging not only the maintenance of growing forests but the reforestation of cut-over lands. The importance of this can hardly be overestimated.

In the report that was read here on the first day of the conference, it was suggested that the lands be assessed for purposes of taxation as though there was no timber upon them, and then when the timber is cut and passed through the saw to tax the output of the mill. That system commends itself to me. Under the present tax laws of many of the States large assessments are put on timber lands, and this is forcing timber holders—the owners of the sawmills—to cut off that timber too rapidly. At least it is having much effect that way. Give them the encouragement to hold back and not force their product upon the markets, and then exempt, by a system of wise tax laws, cut-over lands devoted to purposes of reforestation.

A word or two more, Mr. Chairman, and I will be through. The former governor of California (Mr. Pardee), who a little while ago addressed the conference, referred to three great Presidents, Washington, Lincoln, and Roosevelt. What he said as respects the three I subscribe to, but there is another who is entitled to a place in the front rank. Presidents are to be judged by what they accomplish for the great good of the country they rule. Washington was the grand leader of the forces that founded the Republic. Lincoln was the great leader of the forces that prevented the disruption of the United States. Roosevelt has given magnificent policies to his country, and has pushed it forward enormously in development and added greatly to its prestige and influence among the nations of the earth. He is the President who has exerted that force which is about to realize the dream of Columbus—Columbus, the greatest dreamer of the ages. It is the dreamer that conceives great things. The practical man of affairs comes along and takes them up and works them out. Roosevelt, in this instance, is that practical man. Columbus dreamed of a near passage to the East by way of the West, and inspired by God he crossed the Atlantic Ocean in his three little caravels and landed upon a West Indian island, which blocked his way to the Isthmus. But for that island, and had he escaped the peninsula of Florida on the one hand and the island of Cuba on the other, he would have reached the Isthmus, to cross which was necessary to that "near way to the East by way of the West." It would have barred his passage. We in this day and generation are accomplishing the dream of Columbus. The great nation established on the continent he discovered is doing it. We are cleaving through the Isthmus a water passage. The completion of the Panama Canal is in sight, and when it is cleft through the Isthmus the dream of Columbus will have been realized and our country and the world pushed forward hundreds of years in civilization.

And some day, after this great work is accomplished, upon the two highest promontories along the line of the canal, the American people should erect two statues of heroic size, one commemorative of Columbus and the other of Theodore Roosevelt.

But, Mr. Chairman, I said that there was another great President entitled to be added to the list. A few years ago I made a pilgrimage to Monticello, near historic Charlottesville in old Virginia, and with uncovered head stood at the tomb of Thomas Jefferson, and on the modest shaft of granite that rises over his grave I read this inscription:

> **Here lies Thomas Jefferson, the author of the American Declaration of Independence, of the statute of Virginia for religious freedom, and the founder of the University of Virginia.**

This epitaph was written by himself. It was found among his papers with directions to place it upon his tomb. He had been the recipient of great earthly honors. He had held high stations—minister to France, governor repeatedly of Virginia, and twice President of the United States. But he discarded all these and chose to rest his claim upon posterity to greatness to the three mentioned.

Mr. Chairman, he should have added another. Certainly one of the greatest of his achievements, and which alone would have entitled him to a position in the front rank of Presidents, was the consummation of the Louisiana purchase, by which territory was acquired now forming fourteen great States of the American Union.

If George Washington founded the Republic, Mr. Jefferson, coming shortly after him in succession, doubled the original area of the Republic, gave it dominion from ocean to ocean, and made it possible for Columbia to become, as she is today, the torch bearer among the nations of the world.

PROF. FRANK W. RANE, OF MASSACHUSETTS.

Professor RANE. Mr. Chairman, I simply rose to say that as chairman of the conservation commission of Massachusetts, we are hand and soul in this work with you. I realize it is impossible to discuss all the various points that have come out in this convention. We are here, however, I am sure, to get the backbone of the whole discussion and take it home and get to work.

Recently we have had in New England a meeting of the New England governors, people interested in the subject of forestry and conservation generally throughout that particular section of the country. Recently a meeting of the forestry officials of the six States of New England was held. At this meeting we have discussed and gone over the matter of doing something that we can take to our various legislatures this year, which we hope will bring results. I think forest fires with us in New England is one of the worst difficulties we have to deal with, the question of having some mandatory conditions whereby we can stop fires being extremely important. That is one of the things we are first to consider.

We have been taking up the subject with the railroads and with private individuals, but more particularly getting a definite system of usefulness. I find that there is just as much trouble between our various towns in Massachusetts as there is between various States, and it is necessary to bring them together. We have a system in our own State of Massachusetts whereby we appoint forest wardens in each town. These men are appointed by the selectmen of the town, subject to the approval of the state forester.

From one year's experience I believe that that is going to work out well. With 321 men in Massachusetts representing local conditions, if we can educate those men to be public spirited, to represent their towns, to take back the idea of the State's interest and the nation's interest, we have a natural channel of usefulness. Now, if we can stop fires we can stop them by the individual man on the spot. This man has the privilege of appointing his deputies and discharging them. He has police powers, and he is giving to the State data in regard to fires, the number of fires occurring, the amount of damage done.

Through this natural channel I believe we are going to get to the subject of taxation. We are going to get to the subject of reforestation. I think the natural channel will be found in this way whereby we can touch the man that is really going to do the thing. In Massachusetts we have gotten in touch with our railroad people. They are as much interested in the subject, I believe, as any people, and I believe in New England they are going to take hold of this thing, hand in hand.

We had a resolution, passed last week, that I would like to read if I had the time, but it will be published.

I thank you for this opportunity of representing Massachusetts.

(Thereupon, at 12.35 o'clock p. m., the conference took a recess until 2.30 o'clock p. m.)

THURSDAY AFTERNOON, DECEMBER 10.

The Joint Conservation Conference was called to order at 2.30 o'clock p. m. by Chairman Pinchot.

The Chairman. We will begin what I anticipate will be the concluding session of the conference, so far as any program has been laid out. We take up this afternoon the subject of "Waters," and at some time during the afternoon will probably hear the report of the committee on resolutions.

Ex-Governor Pardee. Mr. Chairman, permit me to move that the report of the committee on resolutions be made a special order this afternoon at 4 o'clock.

(The motion was duly seconded, put, and carried.)

DR. W J McGEE, SECRETARY OF THE SECTION OF WATERS, NATIONAL CONSERVATION COMMISSION.

The Chairman. We will now take up the subject of "Waters." Mr. Burton, chairman of the Inland Waterways Commission, has unfortunately been detained and will not be here to make the opening statement. I will therefore call upon the secretary of the Inland Waterways Commission, Doctor McGee, to take his place.

Doctor McGee. Mr. Chairman and gentlemen of the conference, I shall do no more than ask attention to a few primary ideas with respect to our waters.

In the first place, I should like to emphasize, and have you all join me in emphasizing, the great fundamental fact that water is a resource. Hitherto it has not been our custom to regard water as a resource of a definitely limited quantity. We have been accustomed, after the manner of the ancients, to think of the four elements, of which water is one. We have been accustomed to think of it as free and abundant as the air or the light of the sun, or the wide amplitude of earth. Now, the primary idea which I desire to impress is this, that there is just so much water and no more. In this connection it is necessary also, as I conceive it, and as I hope you all agree, to apply the quantitative method in dealing with water, the same method which we employ in dealing with coal, or iron ore, or any other resource. That indeed is requisite to a clear idea concerning water as a resource—water of which there is only a certain amount and no more. The application of the quantitative method is absolutely essential.

In the report of the National Conservation Commission, which you heard read yesterday, the quantity of water and the sources of the water with which we are blessed were set forth in considerable fulness, I shall not trouble you by repeating the figures in detail. Merely to render clear the primary idea of water as a resource—and I am referring, of course, to fresh water—let us have it in our minds that the sole source is the rain which descends from the heavens. That boon, after reaching the surface of the earth, is divided; half of it is reevaporated, and a portion of this half may be reprecipitated as rain; but we need not follow that half further than to say that after reaching the surface of the globe it is evaporated. One-third of the entire amount flows down to the sea through the rivers, of which many are navigable. There remains one-sixth, and that is consumed or absorbed. On that one-sixth, in the last analysis, depends the habitability and productivity of our country, of every acre of our farm land, and of every acre of our forest land. Nor do we often realize how large a quantity of water is consumed in plant growth and in animal existence. We seldom realize that each average adult man of 150 pounds takes into his system in the course of each year no less than a ton of water; we seldom realize that on the average each bushel of corn requires in the making something like 15 or 20 tons of water. This is an illustration of the fundamental importance of water to the productivity of our land.

Now, to return for one moment to the quantity of water which we receive from the heavens as rainfall. An average of 30 inches over the entire length and breadth of the land, or a quantity equivalent to 10 Mississippi Rivers, is all we have. Without it no acre of our land would be habitable. Without it no industries could exist, and without that one-sixth of it which is largely consumed and absorbed in vital processes the land would be unproductive and sterile, and unfit to form the home of human kind.

The effective fraction of the water descending from the clouds is not that which flows off over the surface during storms; on the contrary, it is that which seeps into the earth in such fashion as to form ground water. Let us have clearly in mind this idea of ground water as a part of the great resources made up of water. How much ground water have we? Of late we have been considering the matter with some care, and we estimate that within the first hundred feet of the surface there is an accumulated body of water, which ought to be but is not quite permanent, equivalent to a reservoir 16 or 17 feet in depth, spreading over the 3,000,000 square miles of the area of our land. That subsurface reservoir is the value on which we must depend for agricultural production, forest maintenance, and the development and continuation of all our industries.

When we speak of that vast reservoir spreading from the Atlantic to the Pacific and from the Lakes afar north to the Gulf on the south; when we think of that stock as the real source of water supply for agriculture and all other industries; when we think of it as the sole source of all our streams, which are fed slowly by seepage through the ground as springs or otherwise; when we think of this reservoir in its extensive applications and endless relations, we must realize that it is no less a national and interstate possession than the air itself. It belongs to all of us. It is the common property of the entire people. And there are those of us who conceive that it must be so administered, and that, proceeding from the navigable streams which we hold should be so improved as to relieve the traffic congestion of the country, we should deal at one and the same time with every aspect of this great resource on which the value of all the rest depends. It is a national possession, and the possession of the several States jointly. The States hold an undivided interest in this great commodity.

This, Mr. Chairman, may suffice to get before you a great subject. I desire only to add that Governor Noel, who is on this platform, Governor Ansell, Governor Deneen, who will arrive shortly afterwards, and Governor Hoggatt, of Alaska, are among those who have the courage to express the convictions of their respective Commonwealths concerning the value of this fundamental resource; nor may I neglect Governor Stubbs, of Kansas, the central State of the nation. We are hopeful also that the chairman of the Inland Waterways Commission, Mr. Burton, will shortly be with us.

I thank you, Mr. Chairman, for the attention that you and the gentlemen present have given me.

GOVERNOR WILFORD B. HOGGATT, OF ALASKA.

The Chairman. In the over-richness of our material in respect to governors I find myself embarrassed, and the only ray of light I can see is to pick the governors who have not yet spoken and give them an opportunity to speak before we call on those who have spoken once. I see Governor Hoggatt, of Alaska, and will ask him to favor us with a few remarks on the subject of waterways. I take pleasure in presenting to you Governor Hoggatt, of Alaska.

Governor Hoggatt. Mr. Pinchot and gentlemen of the conference, this comes somewhat as a surprise, because I am here simply to learn some things that may be of advantage to the country of which I have the honor to be the executive officer and which we may use in the dim future. Most of these questions which are of vital importance to the older States have not yet assumed any importance with us. We have not begun to cultivate the soil, except in very limited quantities, for the purpose principally of furnishing garden truck for our mining camps.

Nature has provided us with a magnificent system of waterways along the coast of Alaska to give us what we need in that respect, and has also given us a river equal in volume, size, and navigability to the Mississippi to bisect the great northern region belonging to the

United States. This river is fed largely from the glaciers remaining in the mountains which divide the coast from the interior valleys, and from those between the Yukon Valley from the Arctic Ocean. Until the glaciers disappear we will have plenty of water in the summer time and lots of ice in the winter. There are some matters which are of great importance to us, which we have taken up and already begun to consider in the line of conservation. The first thing of importance is that of the forests. We have a large area of our country now embraced in forest reserves. We are working out a system by which we can utilize this timber to the best possible advantage and at the same time secure an ample supply for the future. We are confronted with rather a peculiar condition as far as the forests are concerned, and that is that our timber is of such age and growth that a great deal of it has gone to waste from nonuse. One of the most important things is to find some way by which we can use the timber that grows on the coast side of the mountains of Alaska before it reaches the point where it begins to deteriorate. I have noticed in my own experience that the trees grow to a fairly good size and then begin to decay at the heart. We have to find a use for those trees before they begin to decay, or all the strength of the soil will be exhausted by the timber and then no use made of it.

Another thing we have begun to take in hand is the matter of coal. We have found that we have large and splendid deposits of coal. We have it of different grades scattered throughout the whole Territory. In two fields we have bituminous coal that in analysis and steaming qualities is probably equal to anything found in West Virginia. We are endeavoring to find some way by which we can utilize these coals for the present and conserve them for the future without creating any monopolies, and yet reserve all the rights that are proper for the Government without hindering the efforts of our people in developing the field. We are on the road to success in this direction. Of course we all know, as the report of the commission stated, our metal resources are there; and when once used, they are gone forever.

We hope that when the metal resources of the States are largely a thing of the past we will have some left to supply the larger population of the United States.

I thank you, gentlemen, for your attention.

GOVERNOR-ELECT W. R. STUBBS, OF KANSAS.

The CHAIRMAN. Reference has been made by the last speaker to Governor Stubbs, of Kansas. I know we shall be very glad indeed to hear from him, and I will ask him to come forward and address us. I take pleasure in presenting to you Governor Stubbs, of Kansas.

Governor STUBBS. Mr. Chairman, ladies, and gentlemen, when I accepted the chairman's invitation to attend this conference, I did so with the intention of coming here to listen and to learn, and had no idea of having anything to say on the subjects that were to be presented to you.

However, the problems that have been discussed in this conference, in my humble opinion, are of greater import to the American people than any subjects that will be legislated upon in the halls of Congress during this session or the session that is to come.

This subject of waterways and the improvement of the great canals and rivers of this nation has been talked to death. What we need now is action; let us do something. There is not a man in this audience who has considered this subject who does not know that when the States of America ratified the Constitution that we have adopted, they gave exclusive control of these great arteries of trade and commerce to the Federal Government. He knows that this Federal Government, when it accepted this trust, accepted a responsibility from which it can not escape, and that means the development of these arteries, these rivers, these lakes, these harbors, and these canals. For more than one hundred years it has neglected its plain duty and obligation to the people of this great nation. It is no longer a question of knowing what to do or how to do it. There are hundreds and thousands of men who know all about it. It is not a question of material. We have all kinds of material. We have the waterways. We need the money that is necessary to develop these great waterways. It is not necessary for me to talk to you about the benefits that would come to commerce and trade if we had the Mississippi River and its tributaries, including the Missouri, developed with a 14-foot channel—1,500 or 2,000 miles of the Missouri and up the Mississippi as far as we can possibly go.

Such a movement would reduce the cost of transporting heavy traffic at least 70 per cent. The men who have investigated this subject say that the cost would be one-sixth; I will say that the cost would be one-fourth, to be sure to be within proper limits. Waterway transportation means one-fourth of the cost necessary to haul heavy traffic as compared to the present cost by rail. What would that mean against the present condition? What would it mean to Kansas with her 90,000,000 bushels of wheat, sending it down to Kansas City, together with other grain and grain products, if the cost were one-fourth what it now is? What would it mean to Kansas City and Omaha and the cities along the Missouri River, all the way up that great valley, if they could have coal come in from Pittsburg at 50 or 75 cents, or even $1, a ton, and pig iron from Minnesota for one-fourth or even one-third of the cost at this present time? It would not interfere with railroad traffic.

You have heard Mr. Brass tell how in Germany the great waterways haul millions of tons of heavy freight, and that there are railroads on either side of those great waterways that do more business than under any other conditions, that have more business than they can possibly take care of.

This is the greatest economic problem before the American people to-day. It is necessary only to apply simple, sound, business laws. Do you suppose if a private organization or corporation was going to build a transcontinental railroad, they would build a mile a year or 5 miles a year for one hundred years? Would they ever get anywhere with it in that way? In the name of Heaven, what does it mean that the great American nation, the greatest nation of the world, should dillydally and play like children with the greatest problem that ever confronted them in legislative matters? What shall we do, you ask? Ask me whether we can control the Missouri River—and I want to tell you briefly what I saw there.

I have been in the railroad-construction business for twenty-odd years before I blew into politics about four or five years ago. I had a minor part in building a great dike where the Missouri River was cutting pellmell into the south bank of the river there in Kansas. The water was 40 or 50 feet deep and was cutting under that black soil and coming up toward a great railroad track. What did we do? We threw out a lot of willow mats and sunk them with rock and built up a dike that has stood for nearly twenty years, and the great flood of 1903, during which occurred the highest water ever known in the Missouri River in fifty years, only made it stronger and filled it up on both sides.

I say to you there is no trouble about doing this work. It is not a question of how to do it. It is a question of getting the money to do it. You ask, How shall we do this great work? I say you can improve the Mississippi River all the way that it is navigable and the Missouri River for 1,500 miles and all of the tributaries of both of those rivers. You can improve your eastern rivers and your western rivers in eight years just as easily as in eighty years and then get some benefit out of them. How will you do it? Issue bonds at 2 per cent, and all you need to do is to authorize this broad-gauged, big-hearted Secretary Taft, who will be President next year, to go ahead and do this work like a great railroad company would do it. Do what the Congress of the United States did when they started to build the Panama Canal! They would have been a hundred years building that canal if they had put in a piece here and a piece there, and had no plan, no organization, no method.

You can establish a commission, you can put a chief engineer in charge of this great work, you can separate it into divisions, and it will be a mighty poor stick of a man who can not improve a thousand miles of the river, who can not improve all the necessary waterways to the Atlantic seaboard—and that is what we ought to have, right from the Mississippi up through this drainage canal to Chicago and on out to the Atlantic seaboard, as well as down to the Gulf of Mexico. I say to you this is a great problem which confronts the American people, and it must be solved.

What would it cost? Suppose you invest in this proposition a billion dollars, it would be a mere bagatelle in comparison with the benefits that would accrue. I heard Andrew Carnegie say yesterday morning that the benefits would be tenfold greater than the investment. Suppose you invest a billion dollars in the development of these great rivers in the Middle West, the Mississippi and her tributaries, at 2 per cent for fifty years; what would it cost? It would cost $30,000,000 a year for fifty years to pay off this debt. What would this great waterway pay in the way of return? Andrew Carnegie says the income would be $300,000,000 a year, or ten times as much as it would cost, and I believe he stated it conservatively.

What would be the result? It would build up great industries all along the banks of those rivers, develop our country naturally, and give us natural competition in the way of transportation. Are we going to do this thing in a businesslike way, as business people? Or, are we going to play politics and give every Congressman $50,000 or $100,000 for a public building, and give every man a job who wants one, and dole out the billion dollars or two billion dollars without any concrete results? I say to you I expect to see this nation go ahead under the administration of Mr. Taft—one of the greatest men who ever sat in the Presidential chair. I expect to see him finish up the greatest work that has ever been undertaken in the lifetime of the present generation, and that is the work that Theodore Roosevelt has promulgated.

It is a simple business proposition and there is no politics in it, and there ought not to be any politicians in it. It ought to be put on a sound business basis and under the control of good, sound, business men. It ought to be divided up into sections. It ought to be where the men who are now clapping their hands, cheering those sentiments, could see the great boats going up and down those waterways. It would interest us very much to know whether they might have waterway development in one hundred years from now, but I want to see it in my lifetime, and I expect to see it. I have two of the best-looking boys in this whole country, and I am willing to let them help pay the bills in forty or fifty years from now, and they will be glad to have the chance to pay the bills. I think Mr. Taft made a very happy remark the other day when he said it would do these youngsters good to have something to keep them under proper self-restraint. I think we could leave no better legacy to the American people than this great project at least partially completed, and if we do that, it will make this the greatest epoch in the history of the United States.

I thank you, gentlemen.

GOVERNOR CHARLES S. DENEEN, OF ILLINOIS.

The Chairman. I now take pleasure in introducing to you, gentlemen of the conference, Governor Deneen, of Illinois.

Governor Deneen. These internal waterways of the United States which rise in the Mississippi Valley and find their outlet in the Atlantic Ocean or the Gulf of Mexico were, in their natural state as known to the white settlers of the country, divided near the point where Chicago now stands by "one-half a league of prairie." So wrote Joliet, in 1764, after exploring "the Chicago divide." The importance of this fact did not escape the attention of this early discoverer, for in describing a water route from the Great Lakes to the Gulf of Mexico, he continues:

> The route to be taken is this: The bark should be built on Lake Erie, which is near Lake Ontario, and it could easily pass from Lake Erie to Lake Huron, from which it would enter the Lake of Illinois [Michigan]. At the extremity of this lake would be the cut or canal of which I have spoken, to have a passage to the St. Louis [Des Plaines] River, which empties into the Mississippi. The bark, having entered this river, could easily sail to the Gulf of Mexico.

The observations of this early explorer, so natural to one who had penetrated into the heart of the continent by means of its Great Lakes and water courses, were the forerunners of the many others which are to be found embodied in our state papers, beginning with the ordinance of 1787 for the government of the Northwest Territory, which provided for the free navigation of the waters leading into the Mississippi and St. Lawrence, down to the latest report which the present internal-improvement commission of Illinois submitted to the general assembly of that State on April 10, 1907, which demonstrates the feasibility of uniting the waters of those two great systems.

Various causes, however, have intervened from time to time to delay the removal of the slight barrier thus dividing the eastward and southward flowing waters of the interior of the American continent. Lack of means and the transfer from the rivers to the railroads of the bulk of the great freight and passenger traffic of the country have been among the chief causes to contribute to this result.

With the enormous and rapid development of our railroad transportation systems, the navigation of our internal waterways has declined to such an extent that what has been accomplished along the line of waterway construction and improvement has, until recently, been rather of local than of general advantage and significance. An illustration of this is found in the early canal projects which were undertaken in Illinois.

Of these, the first to be constructed was the Illinois and Michigan Canal, extending from Lake Michigan at Chicago to the Illinois River at La Salle, a distance of 97½ miles. This canal was constructed under the authority of a statute of the United States enacted in 1822, followed by a grant of land made in 1827 by the Federal Government "in aid of a waterway from Lake Michigan to the navigable waters of the Mississippi River." Construction work was begun in 1836. Its depth is 6 feet, with a width at the surface of 60 feet and at the bottom varying from 36 to 48 feet. Its locks are 110 feet long, 18 feet wide, and 6 feet deep. Its limited dimensions, together with prolonged low-water periods in the Illinois River, have prevented the canal from developing its full utility. But its incidental effect upon freight rates in its vicinity have been so pronounced that in 1885 Canal Commissioner Brainerd estimated that it had saved the people of the State within reach of its service not less than $180,000,000 in freight charges.

In 1837 the general assembly of Illinois passed "an act to establish and maintain a general system of internal improvements," under which liberal appropriations were voted for the development of river and railway transportation facilities, but, owing to the financial stringency of 1837, no substantial results were accomplished, and in 1840 the act was repealed.

From that time forward numerous projects for the improvement of local navigation in Illinois streams were formulated and surveys made, but no important work was accomplished until the construction of the Illinois and Mississippi, or Hennepin, Canal was entered upon in 1890 for the establishment of waterway communication between the Mississippi River at Davenport, Iowa, and the Illinois River at Hennepin; also affording, through the Chicago Drainage and Ship Canal, whose construction was begun two years later and of which I shall speak hereafter, communication with the Great Lakes. By the natural water route along the Mississippi and Illinois Rivers the distance from Davenport, Iowa, to Chicago is 610 miles. That distance has been reduced by the construction of this canal to 190 miles, a saving of 420 miles between Chicago and all points on the Mississippi River above Davenport, Iowa. This canal has a depth of 7 feet, is 80 feet wide, and has locks of 170 by 35 feet. It is available for boats 140 feet long and of 600 to 800 tons burden.

In more recent waterway construction, however, our State has shared in the awakening to the larger possibilities of waterway development with which the country has entered upon the study of our internal waterways, with a view to their development, extension, and unification upon the broadest scale. This has been evidenced by the interest which the citizens of Illinois have taken in waterway questions in which our State has only a joint interest with others. The Illinois general assembly in February of this year appropriated $10,000 for the investigation of the Mississippi River between Cairo and St. Louis, an appropriation made solely with a view to procuring information which would enable the State to conform its domestic waterway developments to any proposed developments of the main channel of the Mississippi.

The new attitude which we have assumed toward the problem of waterway development has been largely forced upon us by the necessities of our growing internal commerce. The railroads, which for a time provided an adequate, and later a more or less adequate means of transportation for our domestic produce, have now clearly become incapable of meeting demands. In this situation we find ourselves confronted, according to the view of those best qualified to pass upon such matters, with the alternative of a practical duplication of our present railway systems or the transfer to our rivers and lakes of a larger part of the transportation work of the country.

Both the experience of other countries and our own matchless natural facilities have turned public attention toward the waterways in seeking a solution of this problem. Not only is the Federal Government entering upon the task of formulating a general plan of waterway construction which shall treat the work of developing our entire internal waterways system in a comprehensive and systematic way, having regard to the possibilities of intercommunication between and, so far as possible, the unification of its interdependent parts; but the States and localities contiguous to our internal waterways, and which will receive special benefit from their development, are now considering their local projects with due reference to their relation to the general plan.

I think that no feature of waterway development is of greater importance. Other countries, notably France, have had the experience of building independently constructed parts of a general water transportation system upon different scales of magnitude, only to discover with the completion of the system the enormously increased difficulties thereby occasioned and to be forced to correct the mistake by a reconstruction of the work upon a uniform scale. Fortunately for us, we have been forewarned of this danger, and at the inception of a general waterway policy for the country are "getting together" for the consideration of the best methods of carrying out the work with the largest possible local and general advantages.

Great advancement was made in this important direction through the tour of inspection made by President Roosevelt along the course of the Mississippi River from Keokuk, Iowa, to Memphis, Tenn., and the convention at the latter city which brought to a close the President's visit. That gathering brought together the advocates of nearly every local project and those whose interests lay in the development of the internal waterways system as a whole. The mutuality of benefits was there made manifest and discussed and some advancement was made in the recognition of the necessary cooperation between the States and the Federal Government and of the principle that States and localities should contribute to the general program in some proportion to their exceptional benefits.

As I have said, the citizens of Illinois have recognized the larger meanings of local developments. They are also fully aware of the special benefits to be conferred upon their own State through the general development of commercial waterways, and are now carrying forward local waterway work of the most extensive and expensive character upon a scale of magnitude commensurate with any probable future projects of national scope or benefit.

When the sanitary necessities of Chicago demanded the diversion of the sewage of the city from Lake Michigan and the project of constructing a drainage channel was entered upon it was stipulated in the act creating the sanitary district of Chicago, passed in 1889, that—

> when such channel shall be completed and the water turned therein to the amount of 300,000 cubic feet of water per minute, the same is hereby declared as a navigable stream, and whenever the General Government shall improve the Des Plaines and Illinois River for navigation, to connect with this channel, said General Government shall have full control over the same for navigation purposes, but not to interfere with its control for sanitary or drainage purposes.

The channel constructed under this act by the sanitary district of Chicago is the largest artificial waterway ever constructed by man. At a cost of $44,000,000, it has extended the navigable waters of Lake Michigan southward 36 miles to Lockport, establishing water communication between the Great Lakes and the Mississippi and the Gulf of Mexico.

This work has made the establishment of practical commercial navigation between the Mississippi River and the Lakes merely a question of the extension of this artificial channel and the deepening of portions of the Illinois River. For the prosecution of the former work the citizens of Illinois, at the general election held November 3 last, approved a constitutional amendment permitting the legislature to issue $20,000,000 in bonds. One of the most important questions, therefore, which will occupy the attention of the general assembly of Illinois at its forthcoming session will be that of the construction of an additional link in the waterway joining the Great Lakes and the Mississippi. There had been much discussion of this project, of course, prior to the submission to the people of the recently approved constitutional amendment. The internal improvement commission of Illinois, in its report to the general assembly, and in other publications, had called public attention to the possibilities of water-power development in connection with the proposed waterway construction. Its report to the general assembly has shown that between Lockport, the present terminus of the Chicago Sanitary District Channel, and Utica on the Illinois River, a distance of 61½ miles—the stretch of channel to be constructed with the proceeds of the $20,000,000 bond issue just authorized—there could be developed 130,000 electrical horsepower worth $25 per horsepower per annum, an amount capable of retiring the bonds in a period of seventeen years from the inception of the work and thereafter producing a perpetual annual revenue to the State of approximately $2,750,000.

This commission also, in conjunction with the state geological survey commission, is investigating, as an incident to waterway construction and stream development and correction, the resulting reclamation of lands in the Illinois Valley now subject to overflow.

The reclamation of submerged lands, in which the Illinois internal improvement commission will cooperate with the state geological survey commission and the United States Department of Agriculture, is one of the principal items of collateral benefit which are to flow from stream development for navigation purposes. Surveys have already been made by the geological survey commission of the overflow lands adjacent to the Kaskaskia, Big Muddy, and of portions of the Sangamon, Little Wabash, and Embarrass rivers. The submerged lands of the State susceptible of reclamation amount to nearly 5,000 square miles, an area greater than that of the State of Connecticut or the island of Porto Rico, and are, of course, among the richest alluvial lands of the State. It has been estimated that over $100,000,000 will be added to the land values of the State by the reclamation of submerged lands, and that in addition thereto certain portions of the improved streams will be rendered navigable.

In this direction work of a very important character has been entered upon in various Illinois River valleys by local associations formed for the purpose. The possibilities of valley organization for the development of local navigation water power and other collateral utilities are very great. An organization of the character mentioned has been formed in the Rock River Valley having for its ultimate object the development of the water power and other resources of the valley in conjunction with a waterway which shall traverse the valley from the Mississippi River at Rock Island and be eventually extended to Lake Winnebago, to Milwaukee on Lake Michigan, and to the Wisconsin River. The water power capable of development in this valley amounts to 100,000 electrical horsepower, to be developed in part by the aid of storage reservoirs. This power should be worth not less than $40,000,000 as a going concern and represent in industries and growth of population an increased wealth eight to ten times greater. The valley has an area of some 11,000 square miles, located in part in the State of Wisconsin, and its full development involves the cooperation of the people of the two States. Happily, the federal Constitution has provided for such cooperation after securing the consent of Congress and the passage of a federal enabling act.

Another valley which has been given preliminary investigation is the Fox River Valley, almost wholly within the State of Illinois, which has a watershed about one-fourth that of Rock River, capable of developing water power and other collateral utilities of proportionately the same value. I expect to see this movement for valley organization extend, as it should extend, until it comprehends the watersheds of our main streams, and thus through the detailed development of the valleys, in response to local motives, the main streams will themselves receive a large measure of improvement in the form of increased water supply and be furnished with commercial feeders through these tributary valleys. In this manner the policy of conservation and waterway development will be gradually extended by local and state effort, in cooperation with that of the United States, until it will affect every town site in valleys where a stream bed exists large enough to be adapted to waterway development.

The possible and proposed extensions of navigation along some of these streams bear close relation also to another phase of the work of the Geological Survey Commission, that of the development of the mineral resources of the State. The restoration or creation of navigable conditions in many of these streams will carry water transportation into some of the most extensive coal fields of Illinois. I mention this as an illustration of the widening circle of benefits which are incidental to the extension of our domestic waterways. It is not my intention to speak at length upon this subject. I may, however, advert to one other instance of the avidity with which local projects in our State are seeking to avail themselves of whatever advantages may be made to accrue to adjacent communities from the construction of the great commercial waterway from Chicago to St. Louis.

Through the city of East St. Louis, which lies on the eastern bank of the Mississippi River opposite St. Louis, a small stream called Cahokia Creek flows, carrying off the surface water from the adjacent low-lying flatlands. The sudden floods to which this creek is subject have proven a great inconvenience to the city, and plans have been devised for diverting the waters of the creek from their course through the town into an artificial channel 16 miles long, 300 feet wide, and 20 feet deep. This will carry the waters of Cahokia Creek around East St. Louis and discharge them into the Mississippi River 6 miles below the city.

The estimated cost of this work is $6,500,000, and for its prosecution a sanitary district has been formed embracing portions of the counties of Madison and St. Clair, comprising an area 27 miles long and from 1 to 7 miles in width. This sanitary district includes a large and populous manufacturing area and extensive railroad properties, and has an estimated value of $75,000,000. The district was created on September 22, 1908, and the election of trustees will occur on December 16 next. The work of surveying and construction has been placed in charge of engineers of national and international reputation. They are Gen. O. H. Ernst, of the United States Engineer Corps, who for many years had charge of the Mississippi River work between St. Louis and Cairo; Maj. B. H. Harrod, at the time of his appointment and now a member of the Panama Canal Commission, and Maj. D. B. Dabney, of Vicksburg, Miss., who is also in charge of the Vicksburg and Yazoo levee and drainage district.

From these experienced men none of the possibilities involved in the local situation was hidden, and one of the results confidently looked forward to by them and the citizens of East St. Louis is the connection of their surface water channel with the channel of the deep waterway, and the use of the former as a commercial water course. This result will be made possible in the event the plan of the United States Board of Engineers is carried into effect. It is recommended by that board that, instead of using the Mississippi River between Alton and St. Louis, a canal paralleling the river be dug. This will avoid the stretch of river at its intersection with the Missouri, whose cross current deposits an enormous quantity of material in the bed of the Mississippi, demanding constant dredging to maintain a navigable channel. Should this canal be dug, the city of East St. Louis proposes to connect its local channel therewith, giving the city a commercial waterway upon three sides, and furnishing extensive wharfage upon the water side to many of the large manufacturing plants of the city.

No doubt it was the existence of these and other collateral benefits in various localities which reconciled the people of Illinois to the expenditure of so large an amount of public money in waterway construction. In this connection it may be said that there are probably few, if any, localities upon which will fall the burden of waterway construction entirely unrelieved by collateral benefits. In almost every instance the question of waterway development is also a question of the acquisition of water power, of land reclamation, of fisheries improvement, of the betterment of health conditions, of the extension of industrial areas, and the utilization of other incidental benefits, frequently aggregating many times the direct outlay for waterway construction.

This feature of waterway development has received additional exemplification and emphasis of late through the conference held in the city of Washington upon the invitation of the President for the discussion of means for the conservation of our natural resources. The correlation of the different forms of conservation became manifest the moment that representatives of distant and extensive areas, having a great variety and apparent diversity of interests, undertook their joint discussion. The mutuality of interest and the immense possibilties of collateral benefit furnished one of the most hopeful aspects of the waterway question. Whatever the cost of it, the country must perforce, I believe, undertake the improvement and extension of our domestic waterways, and in this situation it is most reassuring and encouraging to find that the necessary initial expenditure will be largely repaid from sources incidental to the main undertaking, and that this will, in addition, provide, through the water power developed, a permanent revenue which may be advantageously devoted to the further extension, improvement, and maintenance of our waterways.

This is especially gratifying in view of the fact that the waterway, as such, will not be a revenue producer. It will be maintained at public expense as an open highway for the free and unrestricted use of the citizens of the country. When we consider what an enormous traffic has been developed upon our lakes we may appreciate the effect of an extension of these magnificent bodies of water through the construction and improvement of navigable channels communicating with them at one terminus and with the ocean at the other, and traversing the rich mining, agricultural, and manufacturing regions of the interior. That the area available for manufacturing enterprises will be thus greatly extended is evident from what has already occurred where water navigation has been naturally available. Many of these enterprises depend for their prosperity upon the cheapness of transportation facilities and these facilties the improvement of our waterways will furnish in abundance.

In this connection I may say that I do not for a moment believe that the development of waterway communication offers the slightest menace to the future prosperity of our railroads. On the contrary, I am of the opinion— now held, I believe, by those who are best informed upon the subject—that in the present congested state of our railroad transportation systems the transfer of a great deal of the heavier, coarser, and slow-moving freight would be a distinct advantage. There is, I believe, a natural and marked distinction between the transportation uses which can be best subserved by the swift-moving railroad service and those which are fully met by the slower but cheaper water transportation.

Statistics show that, in round numbers, one-third of the freight moved by rail is worth less than $1 per ton at the point of production; another one-third exceeds in value $5 per ton; and one-third ranges between $1 and $5 per ton. It is apparent from any study of the cost of transportation of primary products that if these could be handled more cheaply than now, the output of high-class freight would be greatly increased and the railroads would receive a double benefit. They would be relieved of low-grade freight, which they now find it necessary to move in order to maintain the output of high-class freight, and the production of high-class products, which furnish the most profitable class of freight traffic would be greatly stimulated. It will be found further that there are vast resources in our domain which will not bear railway transportation and for which waterways are a necessity if they are to be developed.

It is not my intention, however, to dwell upon particular phases of this broad subject. These will be discussed doubtless by those more familiar with their details than I profess to be. In what I have had to say I have attempted to deal only with some of the general aspects of the waterway question as they have presented themselves to me. It seems to me that in any policy to be adopted for the conservation of our natural resources, the preservation of our navigable waterways for the public benefit must occupy a foremost place, and that the discussion of this very practical and pressing question is of the utmost importance at this time.

GOVERNOR N. B. BROWARD, OF FLORIDA.

The CHAIRMAN. I will call on Governor Broward, of Florida, to address us briefly on this question.

Governor BROWARD. Mr. Chairman, ladies and fellow-citizens from every portion of the country, it is very difficult for one to undertake to speak after others have preceded him, not one or two, but by the dozen, who have carefully studied the problem that we are attempting to solve, and for one to come at this late hour and undertake to talk about something that every one present is perhaps better informed about than he, is to undertake the impossible. It is always poor policy to undertake to make excuses. Persons are not interested in excuses, but I will make the excuse that I have been exceedingly busy since I have been here, and have not had the privilege of listening to those who have already spoken, and who have given this matter careful consideration. Therefore, I approach the subject as a boy might approach the side of the ocean when he is commanded to cross it without boat or oars.

It is fortunate for us that Mr. Pinchot and his splendid coworkers have done so much to place before us the facts that provide us with so much food for thought. Those who first came into this country thought that the forests were exhaustless, that the mines were inexhaustible, and it seems that even up to now there are many of our people who believe that we are on a wild-goose chase, that we are afraid of something that there is no real reason to be afraid of, and that to talk about conserving the forests, or the water supply, or the coal supply, or the iron supply, and all of that kind of thing, is folly.

But if one will only travel over this broad land from one ocean to the other, from the Lakes to the Gulf, he will soon be impressed with the fact that the forests are disappearing rapidly and that those who own them say they are receiving but a very small compensation for the value of the property they are parting with.

In the State of Florida, covered as it once was with tall yellow pine, so that a single acre of land would provide to the miller, perhaps, 10,000 feet of lumber, it has been cut off very largely over the whole State, so far as that State is concerned. The turpentine man has come in and is boxing the trees down to such a size that sometimes cutting a box on one side will cause the tree to fall in a moderate wind. Sometimes fire gets in and destroys many more, and this, with turpentine selling for 35 cents a gallon, which is no price at all for the value of turpentine, even not taking into consideration the great value of the trees to the State in which they are and to the owner of the trees.

We look around the headwaters of our streams and we see the hillsides along the rivulets and branches being denuded of the timber and even the vegetation disappearing in many instances. We can see that the time is near by when that section of the country must suffer from first a drought and then a flood, as there is no foliage to retain the moisture in the land, and therefore it is just as though you would throw a cup of water in a tin basin that will not absorb or retain moisture and then tip it so it will run out; you would have a drought almost as quickly as you would a flood by throwing the water down and letting it run to the sea, unused in many instances, and not retained long enough to be of much use to anyone.

The fact that these gentlemen have gone out into this country and have made these careful investigations, have estimated the value of our water, if used as power, and the many uses to which both the power and the water can be put on its way to the sea, is not only a great credit to them, but will become a great blessing to the people of this country. If the people will act in concert and take advantage of the situation while they may, great good will result. To preserve the forests is necessary. Reforestation is necessary. It matters not whether it comes at a large or small cost, we must provide for the years to come; the not far distant years, but years almost in sight. At the present rate of cutting in the State of Florida, the vast timber areas that I see so graphically described by some man in Michigan as existing in Florida will disappear within twenty years, and twenty years is a short time. I am 52 years old now, and I expect to be here that long. In many instances we cut the timber down, oak scrubs spring up and grow in place of the trees that are gone—not trees with great leaves falling from them to retain the moisture and to fertilize the soil, but a species of bush that does not retain much moisture and does not fertilize the soil by its falling leaves. As a result, the land grows poorer instead of richer.

In the next place, our State has been burned over every year by forest fires. The man who has cattle sets fire to the weeds and grass as early as February and burns the old grass off with a view of having a "new burn," as he calls it, or new grass for his stock. The young pines are burned off that are only a year old, and you can find some sections of the State entirely denuded now. In some sections where by good fortune it has not been burned over regularly you will notice saplings two years old as tall as this room is high, showing how quickly we could reproduce our forests if we would only stop the waste.

I have twice recommended to the legislature that action be taken to protect our forests; that fire districts be laid off and keepers be put upon them to protect the forests from fires, with a view to reproduction of our forests, but so far it seems that the doctrine is that everyone will do all he can to make the dollar in sight and never think of the waste that is taking place. In many instances the man can not afford to consider that. He owes the bank, and the bank has loaned him somebody else's money, and he must go on, though he knows that it is waste, and cut his timber.

That some general plan should be entered upon, understood by the representatives in every State, and some uniform action be taken, goes without saying. It is well for us to be here to consider these things and see what can be wrought out of such work as this. There is not a State in the Union, unless it be out in the Far West, but in my section of the country especially, where the country is not getting dryer all the time, and particularly is that applicable to Florida. Not only do we vote our State dry, but less water is retained there as well. We are getting dryer all the time. It is true there is one portion of our State that has more water than it ought to have. You will notice by the reports that on the east coast of Florida, toward the southern extremity of the State, known as the Everglades, 81.66 inches of rainfall has come to us this year, up to the 12th day of November, beginning at the 1st day of January. I have no doubt we will have fully 8 feet of rainfall by the end of the year. In spite of that the territory is gradually becoming dryer in the upper portions of the State. In many instances the farmers are irrigating their farms. Bankers at Gainesville do not hesitate to lend money to the farmer who will irrigate his crop, and will not lend money to the farmer who does not irrigate his crop, unless he has property other than the crop expected to be produced by the money loaned, which shows the importance of irrigation in one portion of the State of Florida. In the other portion of the State we have now already entered upon a plan to dig 250 miles of canal through what is know as the Florida Everglades, with a view of lowering the level of the water in the land so it may become cultivatable, and with a view also of offering to these people in this country an opportunity for planting sugar cane. With an area larger than Connecticut, Rhode Island, and Delaware combined, almost as level as this floor, covered with a few inches of water most of the year, lying idle with scarcely a tree upon it and nothing but coarse grass, unless the water is reduced from the surface and the land thereby be made sufficiently dry to cultivate, it will never be of any value to us or to the State. It is land which, when drained as we hope to drain it, is as rich as any other in the world. There are a million acres of that land that would produce more than the 30,000,000 acres of other ground in the State, so far as valuable crops are concerned.

We have entered upon this work of drainage in the last four years. Though the land was patented to the State nearly sixty years ago, to aid the State in draining and reclaiming this territory, nothing effective was done with it until recently. In searching the records of the Senate you will find that Senator Breeze, of Illinois, recommended the passage of a similar bill to the one that was passed without amendment, granting to that State all the land lying south of the north end of Lake Okeechobee and between the Gulf of Mexico and the Atlantic Ocean, on condition that the State should drain and reclaim the land and apply the residue to purposes of education. So long ago as fifty-five years, the state legislature created trustees to carry on this work, but the only effective work has been begun within the past four years. Political bodies move slowly. It is necessary that the people shall get behind their representatives and impress them with the fact that they propose to have their work done. All kinds of obstacles are found in the way of an attempt to do any work of this character. As the President suggested the other evening, you will find many difficulties to overcome before you conclude the solving of the problems that are considered here.

We want men with intelligent minds and with strong will. We want to offer one prayer for the people of this nation, if we offer no other, and that is that they will trade off spareribs for more backbone.

We should conclude in the outset that God made this country for the people who are in the country, and not the people for the country. We should appreciate another fact, that this is our country, all of it, and that all of the highways should be used for the people, for the benefit of the commerce of the people, and that the people should not be used simply as a means by which the owners of the highways make money for themselves.

Sometimes when I look this problem duly in the face I see why the bravest of us dodge the problems, and I have really walked around some of the problems until some one discovered me and I had to face them. It is necessary, I believe, that all of us get discovered sooner or later. We must enter upon some plan with reference to these problems. I heard the governor of Louisiana make a speech this morning here. He suggested a plan that he thought feasible. I will not venture a plan upon this occasion, but will make suggestions that we may consider.

I believe our State should retain as much of its own public domain as possible. A small portion of our once proud public domain is left to each of the States. Though Florida was granted by the National Government all of the swamp and overflowed lands within it, and there has been patented to it 20,150,000 acres, yet 17,000,000 acres of that land have been given to railroad and canal companies, so that we now have left only 2,260,000 acres. Every contract made with a company to build a railroad, every grant of land wound up with this language, "and drainage," providing that they should build a railroad on certain specifications, and conclude with the provision, "and drainage," because the legislature thought they had to say something about draining the lands, or they had not a right to give it away, as the land act of Congress expressly required that the land or its proceeds be used exclusively for that purpose. When the statutes were compiled there was included therein this language: "Provided that the lands herein granted shall remain subject to the control, management, and sale of the trustees of the internal-improvement fund for the purpose of said trust under the said act," which trustees were created by the legislature to carry out the contract with the Federal Government to drain the lands. As soon as they would undertake to consider a straight course, then one proposition and another would be offered. Contracts were entered into, but out of all the contracts to drain land less than 20,000 acres were ever truly drained. Now we have entered upon a plan of really reclaiming by drainage the 2,200,000 acres that the State still owns, and about 2,000,000 acres of adjacent land of the same character.

I do not know what the other States have done with their lands. I am afraid that if stock was taken of the public land in those States they would find that the men who were more ambitious than others and who had some special interest to conserve got more than their share. A too liberal policy prevailed in our State; no dishonesty, but they simply got to giving the land away, and it seems we could not stop it. When I was elected governor I declared we would not deed away more land, and proposed to retain what we had and reclaim it according to the former contract with the nation, when great opposition sprang up. Twelve different lawsuits were brought in the federal courts and some in the state courts, and some of them still exist, though we have won at nearly every stage of the fight. Therefore, my countrymen, you can rest assured now that there are obstacles in your road. There are many difficulties to overcome. But, I say to you, overcome them and do not protect the interests of a few selfish people who are endeavoring to obtain the advantages for themselves regardless of the interests of all the other people.

While I am suggesting these difficulties and obstacles which you will have to overcome, I do not want to get in the position of the good old minister, to whom I listened on one occasion. He invited everyone to join his church. He wanted every sinner to come into the fold, sign the roll, and become a member of his church. He impressed the audience with this thought, "It is hard to be a Christian; it takes a man or a woman to be a Christian." And I looked at the little children in the audience and the young people who were about to get married, and wondered what would become of them. He kept on until a Christian looked as heavily laden as does Atlas with the world on his shoulders, and then invited every person to walk up and sign the roll loaded down in that way. The result was that nobody walked up. I do not want you to get too heavily laden, but we must all realize at all times that if we are to succeed we must succeed by individual effort. Everyone should act along some well-defined lines. Write letters, talk to your neighbors, talk to your governor, to your member of legislature, petition Congress. The reason we complain so much of our Representatives in Congress not doing so well for the public generally, but doing well, as we claim, for the special interests is because we do not stand by them. If they stand up and fight for us, we do not stand up and fight for them. The result is they must take the middle course and become very conservative, lest they be left at home entirely and not be permitted to come back to Washington again. We are men and women.

We are human beings, and we are controlled largely by the same influences. The firmest body will turn out of its way any other body of less weight. We are bound as we go along to yield to forces superior to our own, but if all the people will think together, and if the great majority of the people will act together, every other weight or influence must give up to them. We must think. We must be proud of our Representatives. Stand behind them, and if there is one of whom we can not be proud, keep him at home, guard him carefully, and do not let him come up here to harm himself or to harm us. Agitation is necessary to succeed in carrying out any great policy. Cooperation is necessary, and to become acquainted is necessary. You know a great many of our people in the South and in the North and in the West are afraid that we might get too close together and that the Federal Government might get too great a hold upon the hearts and minds of the people of the different sections. There are those who are afraid that this safeguard will be knocked down, and as a result the sovereignty of our States disappear, and all that kind of thing. In all probability there is some danger along that line, but it is not imminent; it is not close by. So far as I am concerned, coming from the far southern portion of this country, I want to say this to you: All of this country looks good to me, and I propose to have any piece of it that I set out to get. I do not know but what I would have it all if I could. In a jocular sense, we have tried one experiment and it did not work. The folks up this way loved us so much they would not let us go; they held us back. I do not think there is anybody down our way who wants to break loose any more, but we propose to come up here and take what you have. We are willing you should come down and take whatever you can find down our way that is not nailed down.

However, while we may speak of sectional lines, let me say to you that there are none. The fellow who talks about sectional lines here, there, or yonder, is a man who has not traveled very far. The more we get about our country and the more we understand each other, the more we think of each other and the less we think of ourselves. It has been said, "If a man would be joyous, look without; if he would be miserable, look within."

Sometime ago I was in the State of Nebraska, and I was impressed with this thing, which shows that when our people think, great good will come from their thinking. The governor and his wife took me out to the asylum first, and we took lunch there. From there we went to the penitentiary and took dinner. After getting inside of the walls of the penitentiary, I said to the warden, "What is your death rate here?" He said, "I have only been here four years. We have had an average population of 408 for the four years, and the only death we ever had during that time was caused by hanging. We hung one man." I said, "Tell me the secret." He took me out to where the prisoners were required to work, thence to the bathrooms, thence to where they slept and lived. The sanitation was perfect. Sanitary conditions could not have been better. The rules were enforced rigidly and good health resulted. No person died in the four years of any disease. The only man who died came to his death from hanging, and of course he could not help that.

Now, my countrymen, this is an indication. This points toward what can be accomplished for the good of humanity, for the health of humanity, and if we will only think and act in the same way, we will have no difficulty in conserving our products. There was an example of the conservation of human life. We can in some similar way conserve our waters. The coal and iron and all of the other riches that bless this country, can be conserved in some way; but it will require careful thinking, careful acting, and when we have careful thought and careful action, the battle will have been won, and we will not only be benefited by it, but our names will be revered by those who come after us; and as I said yesterday evening, of Mr. Pinchot and Doctor McGee and Senator Newlands and all the others who were appointed and who went out to take up this great work of considering the conservation of these natural resources and the purification of the waters and all that kind of thing, their names will be preserved on parchment and hung upon the walls throughout this land, and they will be appreciated throughout all the years to come as persons who looked forward, who thought not only for themselves, but thought that those who were to come after them were entitled to some of the good things of the earth, as well as those of us who are living in this day and age.

When we have each done his full duty in this life, each one will leave it feeling that this work was not half done; that he had only accomplished a small portion of what he would like to have accomplished. I saw the other day a man in declining years and in declining health. When some one asked him how he had enjoyed life, what he had to say, he made this declaration:

> I feel that I have done my best. I did not start early enough, it is true, but for the last twenty years I have worked every hour that I could. I have done well every piece of work that it was my duty to do and that I undertook to do, and I can look up at the planets in their course and say I, too, have done the work that was allotted to me, and I challenge you to do more.

I say this to every person present, that it is the duty of all of us, if we would enjoy that consciousness which a good citizen ought to enjoy, to feel as he goes toward the grave, "I have done all that was in my power, not only for the glory of the God who created me, but for the joy of the people, of my neighbors, for the sake of Him who blessed the world and with whom I expect to dwell throughout all eternity."

I will not keep you here any longer making a rambling speech. My heart is with you. I will do everything in my power in the section of the country in which I live to preserve the forests, to have the water courses properly utilized, to insure to the people of the country the completest use of these natural riches that were put within their reach by the Creator himself; and whether successful or not I shall go out of the fight proud of the opportunity, proud of the part that I took in it, and having no regret except that I had not accomplished more.

I thank you for your kind attention.

GOVERNOR ROLLIN S. WOODRUFF, OF CONNECTICUT.

The Chairman. I now take pleasure in presenting to you Governor Woodruff, of Connecticut, and I know we shall all be glad to hear the message he has for us.

Governor Woodruff. Mr. Chairman, ladies and gentlemen, I have enjoyed all of the exercises of the past two days exceedingly from the very fact that my name has not been on any of the programs, and I have not been obliged to think that I was going to be called upon to say anything. I am, however, glad to appear before you to represent our little State of Connecticut. We are a small State. We are a manufacturing State. We have no mineral resources. We have no waterways that need developing. We have, however, Long Island Sound, which helps our manufacturers to get raw material at moderately low prices. We are simply a producing State. We have the reputation of manufacturing some things, but that reputation is not well founded. We have been accused of manufacturing wooden nutmegs, but I assure you, gentlemen, that is not true. We have, however, in the past produced many things and a great many things that have been produced for the first time.

We produced a constitution, the first written constitution, and the United States Government copied after it. We have produced a great many men who have been prominent in this country. We are proud to say that we have a living example right here of our own product—Mr. Pinchot.

We concur in everything that has been brought out here in all these great questions which are being discussed. There is no State which will receive greater benefit if these projects are carried through than will our little State of Connecticut. We need raw material because we are producers, we are manufacturers, and none of you, no matter from where you came, can go into any hardware store or agricultural-implement establishment where you will not find some of the products of our Connecticut.

We stand ready with the other States to take any action that may be necessary to bring about all of these good things which you are considering. It is simply a question of education, gentlemen. You can not expect to wake up to-day, walk up to the National Government and present your case, and expect that they will open the strong boxes of the Treasury and hand over to you the necessary funds to carry out these projects. The people must be educated. They must be so thoroughly educated in all these questions that these Representatives in Congress will absolutely be forced to give you what you want in a reasonable way. All this takes time. Mr. Pinchot, in his forestry work, has done a remarkable work. It is only a few years that he has been at it, and he is responsible for bringing out all that has been done in the way of forestry.

We have no forests in Connecticut. We have a few wood lots. Our State appropriates a very small sum to our state forester to-day to enable him to do some things, and he has done them in a small way, mostly in an experimental way, but he has shown what can be done.

Within the last two weeks our New England governors have come together and considered certain common laws which were for the benefit of all of our New England States. We had a conference week before last similar to this, in which the question of forestry, the question of the cultivation of the lobster, the question of good roads, and the question of a uniform automobile law were considered. We propose to have in New England a uniform automobile law, so that when you gentlemen wheel into New England you will know that the law throughout New England is the same. I believe that the States can come together in this way and accomplish a great deal. It is right along the same lines that we are considering here, and a great deal can be brought out of it. I do not know that I have anything more to offer at this time, Mr. Chairman. I am highly pleased to have been called upon to represent our State at such a meeting as this.

I thank you very much, gentlemen.

Mr. PAGE, of Virginia. Mr. Chairman, I rise to a question of personal privilege. I am perfectly willing to accord to the great State of Connecticut all the wonderful work she has done, and I am willing to say in behalf of the country that in the production of Mr. Pinchot she has done probably her greatest work, so far as that may be concerned. But I must say, in behalf of Virginia, that I do not admit that Connecticut was the author of the first Constitution of this country.

EX-GOVERNOR SAMUEL R. VAN SANT, OF MINNESOTA.

The CHAIRMAN. I will now call upon Governor Van Sant, of Minnesota, for a few remarks. I take pleasure, gentlemen, in presenting to you Governor Van Sant, of Minnesota.

Ex-Governor VAN SANT. Mr. Chairman and gentlemen, it has seemed to me since I came to Washington that every person I met was either an officeholder, an ex-officeholder, or willing to be an officeholder. I was introduced as governor—I can not for a moment sail under false colors. Minnesota can have only one governor, Governor Johnson. So you see I am not a distinguished statesman, but an extinguished one—only an ex-governor, if you please.

For more than thirty years I have been actively interested in the waterways of our country. I am a steamboat man, and had thought until I came to this meeting that I was the only steamboat captain who was ever the governor of a State, but I have since learned that the governor of Florida was also a master of steam vessels, so I have to divide that honor with him.

I have just come from the River and Harbor Congress. It is a great gathering of splendid, determined American citizens. I predict a speedy improvement of our waterways. Those men mean business, and in time will get what they have so long contended for.

There has been such an aroused public sentiment that practically every commercial body, chamber of commerce, board of trade throughout the length and breadth of the land favors this great movement; and I doubt if any candidate for Congress, in either party, in any State of the Union, would have the temerity to stand up before election and say to the voters in his district that he was opposed to the improvement of the waterways of our country.

In my judgment, when we have a perfected and completed system of waterways, it will do more to solve the rate problem—in fact, the whole vexed transportation question—than all the laws that we may be able to put upon our statute books.

I am glad to look into the faces of my coworkers in their efforts to conserve our forests, for I am also a delegate here. I promise you that so far as my ability and my strength go I am with you heart and hand, and will aid you in every measure that will help to preserve our forests; for in doing this I feel that we are advancing the interests of our waterways, for forests are essential if we are to have a sufficient water supply.

Yes, I will join hands with you and do all that I can; but we must remember that if we want anything we must not only ask but fight for it. This is a fighting age. Yes, we must not only ask Congress for aid, but we must fight, and fight hard. This is a representative government, and we send men to Congress to represent our views, and if we do our whole duty and make our wants known the Members of Congress will be only too glad to carry out our wishes. I think I know what I am talking about. No one has his ear to the ground and keeps it there longer than the officeholder, and no one is quicker to discern public sentiment than he, and to trim his sails accordingly.

I am not a pessimist; I am an optimist. I have no fear of the result. When I read the history of my country, I learn that we have met and overcome every obstacle in the past, and I am sure we will meet the difficulties which confront us now, and master them, too.

It is very gratifying to be here for another reason. It is a pleasure to meet the delegates from Florida, Georgia, and Louisiana, and from other portions of the South. We are united now for a common purpose and have no North, no South. I am glad indeed to meet so many ex-Confederates. The war is over and if these ex-Confederates will fight as hard to preserve our forests as they fought when I was in the Union Army and pitted against them, I am sure we will win, especially as we are all fighting for the same cause. United we can get anything we want.

Yes, the war is over, and I am glad to say in this presence that the warmest greetings and heartiest handshake that an old soldier gets is when he goes south and meets an old grizzled Confederate veteran. With the old soldiers on both sides there are no longer any animosities. The asperities of that great struggle have passed away. So I say it is a great pleasure to see so many public-spirited men from the Southland, who join with us in the effort to bring blessings to millions yet unborn.

Other gentlemen have spoken gloriously of their States, but it is not necessary for me to tell you of the glories of Minnesota. Governor Johnson has undoubtedly done that, and in the best possible terms. I can not, however, resist the opportunity to say a word about the North Star State. It is most fortunately situated in the center of the North American continent and midway between the Atlantic and Pacific and the farthest point toward the setting sun reached by tidewater navigation. It has two great waterways to the ocean; one via the Mississippi River, the other from Duluth via the great chain of lakes, and still another, if ever made necessary by a greatly extended commercial trade, via the Red River of the North and Hudson Bay. We raise the wheat to feed the world, have the largest mills in the world to grind it into the best flour ever made. We have iron ore enough to supply the wants of mankind for a century to come. Our forests for half a century have enriched our people, and have supplied surrounding people with lumber to build their happy homes. We have ten thousand beautiful lakes, and from this fact Minnesota received her name, the land of sky-tinted water. We also have numerous rivers, and our lakes and rivers teeming with fish and our forests alive with game make Minnesota the paradise of the sportsman. We have a vast area, the State being larger than all New England, New Jersey, and Delaware, and have more square miles than England and Ireland combined. Our climate is unsurpassed. The afflicted people of all States come to Minnesota to breathe her exhilarating air and to renew their youth. Yea, Minnesota ozone is famous the world over. A story will illustrate: A man from Florida, Georgia, or some other State, was very near death's door. His physician told him he could not live unless he changed climate and suggested Minnesota as the best place to go. He followed the advice, and after remaining in our State a few weeks he wrote back to his friends that he was getting along finely and that he felt twenty years younger. In due course of time his improvement was so great he wrote that he felt thirty years younger, and still later that he felt forty years younger. The next they heard from him, he had died with cholera infantum.

These conditions, however, do not constitute a State. Better, and above all, we have 2,000,000 happy, contented, and prosperous people, and these are Minnesota's greatest asset. But I must not tell you all the good things about our great Commonwealth; I fear I would do you a great wrong, for you might be induced to leave your present abodes and move bag and baggage to the great Empire State of the West.

GOVERNOR MARTIN F. ANSEL, OF SOUTH CAROLINA.

The CHAIRMAN. I am going to call upon Governor Ansel, of South Carolina, to give us a short address on this subject. I know we shall all be glad to hear from him about this matter.

Governor ANSEL. Mr. Chairman, ladies, and gentlemen, I have had one chance at this audience, I do not know why I should be called upon again this afternoon unless it is for the reason that I am a water man, interested in salt water, interested in fresh water, and am on the water wagon. You all know what the governor of North Carolina said to the governor of South Carolina. The last message that I have received from my distinguished friend, Governor Glenn, is that we want water, water, more water.

I represent in this body primarily the State of South Carolina, but also the whole United States. We are here to devise ways and means for the best interests of every State and of each State and of all the States. As you know, in South Carolina we have on one side the Atlantic Ocean. Therefore we are interested and greatly interested in navigation. We have in the other portion of the State the mountains, where they do not make sunshine, but sometimes they do make a little moonshine. We have fresh water there and we are beginning to take measures at this very time to utilize this great commercial asset that has been going to waste for years and years, and we are churning our waters from their very source until they get nearly to the Atlantic Ocean, and then we make ice out of them. One hundred and seventy-five thousand horsepower of that water is utilized at this very day for the purpose of making electric power, and we have 375,000 horsepower of water still to be utilized and to be used. That is in the nonnavigable streams of our State. Are we not interested in water?

We are interested in forests as well, because the sources of many of our rivers are in our mountainous country, where the trees are being cut down. I do not know when I have felt as badly as I did last summer a year ago, in looking at one of the mountain sides that I used to see covered with forests when a boy, large and small trees, and I asked, "What is the matter with that mountain side?" It was bare. I was told that a little sawmill had been put up there, and instead of having that loam soil that we have upon our mountain sides, it was going down into the creeks and into the rivers and into the sea, causing this great Government to have to spend money in dredging the navigable streams of our country, in order that the ships may float and carry the produce that is raised in this great country of ours.

I just wanted to say a few words by way of exhortation, but fear I might do as I have often heard done—spoil a good sermon by a very poor exhortation. I want to say that I am with you in this great work of preserving all of these bounties that have been so largely bestowed upon us, preserving them for our posterity—the waters, the forests, the lands, the minerals, which are the great riches of this country. Whether they be used in the next century or the two centuries or the next three centuries, let us preserve them for our posterity, in order that they may rise up in later years and call us blessed.

REPORT OF COMMITTEE ON RESOLUTIONS.

The CHAIRMAN. Gentlemen, the hour has arrived for the special order of business, and we must proceed to that business. It is a matter of very sincere regret to me that our time is so short, as I know it is a matter of regret to all of you. Possibly there may be a chance that some of the gentlemen who certainly ought to be heard may have an opportunity after we consider the report of the committee on resolutions.

I will ask Governor Pardee to present now the report of the committee on resolutions.

Ex-Governor PARDEE. Mr. Chairman and gentlemen, your committee on resolutions has had two or three meetings, and the opinion prevailing among the members of the committee was that the prime object of this meeting was for the purpose of either indorsing or refusing to indorse the report of the National Conservation Commission, which was appointed by the President, and has been holding its meetings during the last week or ten days here in Washington. Various resolutions on other matters specific in their nature were presented to the committee; some of them have been withdrawn by the gentlemen who introduced them, others have been considered of such specific importance by the committee on resolutions that they resolved to refer them to a committee which is called for in a resolution here to be presented, and others will be presented by us at this time. As I say, the report of the committee on resolutions embodies primarily the indorsement of the report of the National Conservation Commission, which will be presented to the President. The report of the committee on resolutions reads as follows:

This joint conservation conference in session assembled in the city of Washington on this 10th day of December, in the year 1908, representing the several States and Territories of the United States through governors of States, state conservation commissions, delegates, and representatives of state and national organizations dealing with natural resources, does hereby resolve and declare:

Having heard the report of the National Conservation Commission read, and having fully deliberated thereon, we hereby indorse the said report as a wise,

just, and patriotic statement of the resources of the nation, of the thoughtless and profligate manner in which some of these resources have been and are being wasted, and of the urgent need for their conservation in the interests of this and future generations, to the end that the prosperity and perpetuity of the nation may be assured.

We especially approve of the principle of cooperation among the States and between these and the Federal Government laid down in that report and in the earlier report of the Inland Waterways Commission, and urge both state and federal legislatures to enact such laws as may be necessary to extend and apply such cooperation in all matters pertaining to the use and conservation of our resources.

We especially commend and urge the adoption of the policy of separate disposal of the surface rights, timber rights, and mineral rights on the remaining public lands of the United States; and we approve the disposal of mineral rights by lease only, and the disposal of timber rights only under conditions insuring proper cutting and logging, with a view to the protection of growing timber and the watersheds and headwaters of streams used for navigation and other interstate purposes.

We also especially approve and indorse the proposition that all the uses of the waters and all portions of each waterway should be treated as interrelated; and we emphatically urge prompt and effective legislation providing for the immediate and proper development of the waterways of the country for navigation, water supply, and other interstate uses, preferably by direct federal appropriations; otherwise by the issue of bonds.

Approving those portions of the report pointing out the need for continued investigation and more extended scientific research, we also urge that this policy of gaining more definite and specific knowledge relating to our resources be adopted by the several States no less than by the Federal Government.

Especially commending the portions of the report dealing with diminished national efficiency due to disease and premature death among our citizens, we urge the adoption of the policy of protecting life and health by States, municipalities, and communities no less than by the Federal Government; and we urge further investigation of all other means whereby the efficiency of individual citizens, and hence of the States and nation, may be increased.

We favor the maintenance of conservation commissions in every State, to the end that each Commonwealth may be aided and guided in making the best use of those abundant resources with which it has been blessed.

We also especially urge on the Congress of the United States the high desirability of maintaining a national commission on the conservation of the resources of the country, empowered to cooperate with State commissions, to the end that every sovereign Commonwealth and every section of the country may attain the high degree of prosperity and the sureness of perpetuity naturally arising in the abundant resources, and the vigor, intelligence, and patriotism of our people.

Ex-Governor PARDEE. I move the adoption of the report of the committee.

(The motion was duly seconded.)

Senator SMOOT. Mr. Chairman and gentlemen of the conference, I wish at this time, as I did in the committee, to reserve the right in voting upon this report to say that I am rather doubtful in my mind as to whether a law can be passed that would be successful in the United States, especially in the western parts of this country, in the separation of the surface rights from the mineral rights. In saying this I simply refer to lode claims and placer claims. I approve of the principle, if it can be carried out successfully, but in my opinion, knowing the country as I do, where lode claims are numerous and especially as to the placer claims, the surface itself is the ground which contains the mineral, and I reserve the right at this time, as I have suggested, to make this statement, so if I am ever called upon at any time to act upon this I will not have my action or vote here pointed out as my position on the matter.

Senator NEWLANDS. I would like to ask the Senator from Utah whether he thinks this report covers lodes and placer claims? Was it not only intended to apply to consumable minerals, such as coal and iron, and not to the precious metals, gold and silver.

Senator SMOOT. I thought that the report was rather sweeping in its statement, because it says, merely, "mineral rights," and is not specific as to what minerals are included, and I therefore took it for granted that in adopting it, it would mean all of the minerals.

Ex-Governor PARDEE. As many in the committee thought it was almost if not quite impossible to make any reservations, the general idea of the committee and also of the commission was and is that this should refer particularly to these great bodies of consumable minerals, and that whatever portion of the surface of the land may be necessary for the working of the nonconsumable minerals of the country would be freely granted to those people who are working the resources of the country for the purpose of securing those minerals, but that no agricultural land should be given to miners and held by them in great tracts for the purpose of holding and controlling at the same time the gold and the iron and other minerals lying beneath the surface.

Senator SMOOT. Mr. Chairman, I presume Governor Pardee knows I am in full accord with that, and the only suggestion I had at this time was that I wanted a record of this, so that no technical matter could be brought up in the future, but that we in this gathering here virtually understand the question and that we are more particularly referring to minerals that can be consumed rather than precious metals.

Senator NEWLANDS. Mr. Chairman and gentlemen, I should like to say a few words regarding the machinery which, in my judgment, legislation should provide for this constructive work regarding the waterways.

In my judgment, the period of agitation is nearly over and the period for actual construction is come. Public opinion is now formed upon the subject of the development of the waterways throughout the country. It has so impressed itself upon the action of political parties of the country that both parties, in recent national convention, have declared themselves unequivocally for the full development of all waterways for every use to which civilization can put them. You will find clear, unequivocal statements upon this subject in both platforms, and it remains now for Congress to carry out the pledges which the great parties have given to the people. This is the real question now before us.

You have appointed a committee consisting of a representative from each State in the Union to appear before the Committee on Commerce of the Senate and urge the views of this conference regarding the development of our waterways. There is not a man on that committee who does not favor the development of our waterways, but the question of the machinery under which that development shall be accomplished is an open question. It is that question upon which they will wish to hear from you. Are you satisfied with the machinery which thus far we have had? The views presented by Members for particular projects are freely aired at the committee meetings. The bills concerning the matters are referred to the Engineer Corps of the Army for their opinion, are then later acted upon by the committees of Congress, and then by Congress itself. Those methods of course have been improved in late years under the admirable administration of Mr. Burton, of Ohio, as chairman of the Rivers and Harbors Committee.

But the energies of Mr. Burton, I imagine, have been directed more in the line of preventing pernicious projects than of advancing real constructive projects. We all realize that Mr. Burton has been an overworked man, so much so that he proposed to withdraw from the chairmanship of that committee at the last session of Congress, because he found that his time was exclusively taken up in its work. He desired to apply himself, as he is well fitted to do, to problems of general statesmanship. If Mr. Burton should retire from that committee, how long will it be before we can get another man who will acquire the same experience and who will manifest the same interest in his work that Mr. Burton has? The difficulty has been thus far that Congress has been endeavoring to do not only legislative work but executive work, and we have not had the assistance in the execution of a great work of a great number of government experts who could furnish us all these various projects in an uncompleted form, determine their merits and their relative importance, and weave them all into one connected and comprehensive plan, and when a project was determined to be feasible, immediately enter upon the construction of the work.

We have been engaged in river and harbor work ever since this Government was formed over one hundred years ago. We have expended over $500,000,000 in river and harbor improvements, and outside of the harbor improvements, many of which have been admirable, we can hardly find any appreciable results so far as the navigable rivers of the country are concerned. We have witnessed the development of the pork barrel, under which process each of the Members of Congress scrambles for position upon these committees, with a view of securing the advancement of his project in his particular district, not engaged in the formation of comprehensive plans, not looking out for the interests of the entire people, but simply looking at the particular project in which the particular district may be interested, and that particular district content provided a large amount of money is expended, whether the project be meritorious or not.

I heard the Speaker of the House of Representatives before the Rivers and Harbors Congress this morning speak upon this subject. He gave the history of legislation upon this subject and showed the advances that have been made, and among other advances declared that in the Fifty-first Congress, nearly twenty years ago, the Government had entered upon the contract system in river improvement, and he held up his head and said, "Thank God for the contract system." Think of a government which has been in existence for nearly one hundred years engaging in river and harbor improvements without seeing the merits of the contract system; and if it takes the Congress of the United States nearly one hundred years to ascertain the advantages of that system, I ask you how long it will take Congress to frame a connected and comprehensive plan regarding the development of our waterways?

I am a Member of Congress, and I do not wish to belittle the capacity and usefulness of that body, but I do say that it has seized upon and held powers for years that do not properly belong to it.

It is the disposition of every person and of every organization to seize as much power as it can and to exercise it, and Congress has been jealous of giving up any portion of its power upon these questions, and will be in the future.

The other day a prominent Member of Congress asked me what I thought as to the advantages of having a commission. He said, "I feel that I can get more from a committee of Congress than I can from a commission." He did not realize the significance of his utterance. He was an advocate of the system that enables a Congressman to get as much as he wants for his particular district or for his particular State, whereas the advantage of a commission is that it does not yield at all to political interests, but it determines those questions according to the scientific relation of them and the scientific importance of the projects, and it knows no district, knows no State, knows no section. I do not believe we can ever enter upon a constructive plan properly that involves this collision of interests that a legislative body will necessarily be involved in.

So the contest which we have before us is not one as to the advisability of entering upon the improvement of our waterways, but as to the methods under which this great work shall be conducted. I wish to say just a few words upon that subject, particularly with a view to impressing certain considerations upon the minds of the committee of this body that is to meet the Committee on Commerce of the Senate to-morrow.

The men who have given most thought to this subject have concluded—and I think they are supported by the judgment of the country—that in order to enter upon this great work it is necessary to have an ample fund provided, and a fund that is not subject in the future to the contingencies of legislation; a fund which, if not kept good by legislative appropriation, will be kept good by bond issues, so that the commission which enters upon this work can plan a long way ahead and can see before it the means with which to engage in consecutive work. Consecutive work is a most important element in this matter; not the disjointed work that we have had in the past; not work here and work there, interrupted now and then by intervals of one or two or three years.

It is also important that we should have a board or a commission—it is frequently styled an inland waterways commission—and the President should be given the power to appoint such a commission and remove the members thereof whenever he sees fit. The responsibility of this great work should, in my judgment, be put upon some one man, and obviously that man should be the President of the United States, in whom all the executive power of the United States is vested. I would allow him to select the officials through whom this work is to be done, with requirement that reports be made to him, with requirement for frequent reports to Congress and submission of plans and estimates and expenditures both to the executive and legislative bodies of the country. I would also provide—and I say I, but I think this is a sentiment indorsed by the Inland Waterways Commission and by the men who have thought upon the subject—for coordination in this work through this commission of the various bureaus of the Government whose work in any way relates to water, such as the Forest Service, the Reclamation Service, the Geological Survey, the Weather Bureau, so that the accumulated experience of all those bureaus and the officials connected with them and the accumulated capacity of all those bureaus and officials can be compiled in the constructive work upon which we are about to enter. Then it is desirable, of course, that that board or commission should have the power of cooperation with States and municipalities and individuals, for we will find that we will have to deal with all in the development of a river to its highest usefulness. In addition to this, we must have provision for bond issues. The fund should be kept good. That fund should be not less than $50,000,000 at the start, set aside in the Treasury for that purpose, with authority to the President of the United States, whenever the fund is reduced below $25,000,000, to issue 2 per cent bonds in order to make the deficiency good, so we will have a continuous fund which can be kept good, by Congress through appropriations, if it so desires, but it must be kept good, if Congress does not act, by the action of the executive department.

These are the essentials : An ample fund, power given to the President to act, full responsibility put upon the President, power given to him to appoint a commission, power to bring into coordination with this commission all the related services of the Government, power, whenever the fund is lessened by expenditure below $25,000,000, to increase the fund.

You will find great objections to this among the Members of Congress. You will find unwillingness to relax power. You will find unwillingness to relax their power of determining what the project shall be; but it seems to me that this commission should be given the full power, with the approval of the President, whenever the project is determined by them to be feasible, to immediately commence the construction of the work. We have had this experience in the irrigation service. There were 15 States and 3 Territories interested in irrigation. After public sentiment throughout the country had determined that national irrigation should be commenced, we found that the sentiment of those States was so divided as to the methods of operation as to where the first project should be commenced, as to what the amount of the appropriation should be, that we finally, in order to avoid conflict among ourselves, which would injure the cause before the entire country, created a reclamation fund out of the sale of public lands and put the entire fund under the control of the Secretary of the Interior, giving him the power to employ engineers and experts, and, whenever he deemed a project to be feasible upon such reports, to immediately enter upon construction, and the result is that after five years of operation the irrigation service to-day can show more effective work than can be shown by the rivers and harbors forces of the country during the entire history of the United States.

The irrigation service has entered upon work with reference to 23 separate projects. It now has in its funds, from the sale of lands, over $40,000,000. Every State in which these works are being conducted is a State that has progressed. The entire service has been taken out of the politicians' hands, and in this respect the pork barrel does not exist.

I will not take more of your time upon this subject when time is so precious, although the subject itself is one that is a constantly broadening sphere of suggestion. I simply wish to impress this upon this conference and upon this committee that is to meet the Committee on Commerce to-morrow. Let them not waste any time upon the general advantages and the general importance of the waterway transportation and of waterway development. Let them address themselves simply to the practical work of organizing a great constructive commission, composed of engineers and experts who can investigate, and after investigation and the approval of a project by the President of the United States, can enter upon immediate construction.

(Thereupon, without further discussion, the resolutions offered by the committee on resolutions were adopted as submitted.)

FURTHER REPORT OF COMMITTEE ON RESOLUTIONS.

Ex-Governor **Pardee**. The committee on resolutions further desires to offer the following:

Resolved, That a joint committee be appointed by the chairman, to consist of six members of state conservation commissions and three members of the National Conservation Commission, whose duty it shall be to prepare and present to the state and national commissions, and through them to the governors and the President, a plan for united action by all organizations concerned with the conservation of natural resources.

Mr. Chairman, I move the adoption of that resolution.

(The resolution was unanimously adopted.)

Ex-Governor **Pardee**. The committee on resolutions has instructed me to present the following:

Resolved, That the question of the desirability of and ways and means for publishing the proceedings of this conference be referred to the joint committee of nine provided for by a previous resolution, with power to act.

Mr. Chairman, I move the adoption of that resolution.

(The resolution was unanimously adopted.)

Senator **Newlands**. Mr. Chairman, at the suggestion of Doctor McGee, I desire to offer the following resolution and move its adoption:

Fully approving the policy of improving the waterways of the country for navigation and other interstate uses of the waters, we urge the prompt adoption of the broad plan recommended by the Inland Waterways Commission for waterway development under an executive board or commission appointed by and acting under the direction of the President of the United States.

(The resolution was unanimously adopted.)

Mr. **Cuttle**, of California. Mr. Chairman, I understand the committee on resolutions considered and recommended with reference to the report of the national conservation committee only. I have been asked to present the following resolution:

Whereas the destruction of the timber on the watersheds of the rivers of the United States causes the flow of water to fluctuate between floods which cause incalculable damage, and extreme low water, which destroys the utility of the rivers for navigation, water power, and water for domestic use and irrigation: Be it

Resolved, That we recommend that the several States enact laws regulating the cutting and removal of timber and slash on private lands to the end that the continuity of the forests of our country may be assured; that damage from floods may be prevented; that a more uniform flow in rivers may be maintained for the benefit of navigation, water power, and water for domestic use and irrigation.

Mr. Chairman, I move the adoption of this resolution.

(The resolution was unanimously adopted.)

Mr. **Evans**, of Pennsylvania. Mr. Chairman, I desire to bring out in this national conservation work these seventy-odd national bodies, at least national in scope, which were thought worthy of being invited here as conferees. We of course desire their good will. They are worthy of consideration in forming a national policy for this work. I move you, therefore, that these conferee bodies be invited to send in, to be incorporated in the proceedings of this meeting, their suggestions and views as to how they can cooperate in this conservation work.

Mr. **Rice**. Mr. Chairman, I would like to suggest that that motion include the proposition of sending from some central source to these separate organizations the information that may thus be contributed. Let the National Conservation Commission receive the advice and suggestions from the organizations throughout the United States, and then that advice should come back to them in a compact form.

The **Chairman**. As I underestand the suggestions, they are that the national organizations invited to attend this conference be asked to give their advice and suggestions to the committee of nine which is to be appointed as to how they may best join in this movement, and that the committee of nine thereupon communicate with them in turn, transmitting to these various organizations the suggestions and advice thus received and tabulated by the committee of nine.

(The suggestions were unanimously adopted.)

Governor **Noel**. Mr. Chairman, I move that the chairman and secretary of this conference be added to the committee of nine and constitute a part of that committee.

(The motion was unanimously carried.)

The **Chairman**. By the courtesy of the meeting, I have an announcement to make.

I take upon myself the liberty of suggesting to the conference that it authorize all members who have papers or discussions, which they have not been able to submit, to send them in for incorporation in the final report. That matter has been submitted to this committee of nine, and it seems to me that the conference itself ought to take action upon that matter. Without objection. the chair will assume that the secretary of the conference, pending the action of the committee of nine, will be empowered to receive these communications and hold them.

Second, I desire to suggest that you allow your chairman to suggest to the authorities of the hotel the appreciation which undoubtedly you have, as I have, of their courtesy and the way they have treated us while we have been here.

Governor **Ansell**. I offer that as a motion, Mr. Chairman.

(Motion carried.)

Mr. **Lay**, of Alabama. Gentlemen, I move that we extend our thanks to our worthy chairman for the many courtesies and the patient and able manner in which he has handled this meeting, and for the energetic work that he has done in behalf of the cause for which we are here assembled.

Mr. **Cuttle**, of California. I second the motion.

(Motion carried.)

ANNOUNCEMENTS.

The CHAIRMAN. I have two more announcements to make, and then there are one or two gentlemen who ought to say a word before we adjourn.

In the first place, the Vice-President, Mr. Fairbanks, has requested that I give notice that all members of this conference are invited to a reception at his house this afternoon between 5 and 6 o'clock, at 1701 K street.

Second, may I ask you not to forget my mother's invitation and my own at 9 o'clock this evening, at 1615 Rhode Island avenue, it being understood that this invitation is not only for the gentlemen who are members of the conference, but to the ladies who are members and to the ladies who may have accompanied the gentlemen members. We greatly hope to see all of you there.

Will you, for two or three minutes apiece, listen to two or three gentlemen who have been trying to get recognition, provided they limit themselves to that time?

MR. EDWARD G. ACHESON, PRESIDENT OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

The CHAIRMAN. The first gentleman I shall call upon to address you will be Mr. Edward G. Acheson, president of the American Electrochemical Society.

Mr. ACHESON. Mr. Chairman and fellow conferees: I appear before you as president of the American Electrochemical Society, and I am very grateful for the opportunity to bring to your attention a few facts that justly entitled electrochemistry to be considered one of the most important factors in the conservation of our exhaustible natural resources by the utilization of water power.

Since this conference convened we have had it impressed upon us that we are the first to take an active national attitude toward the conservation of our great resources. We have been told the lives of some of our most valuable assets, as the coal, oil, and iron, are to be measured in one-half, one, two, or three centuries. A century may be long when measured by our lives, but quite short in the life of a nation or in the span of life on earth. It is indeed rather startling to me when I think of the fact that my own short life has covered the one thirty-eighth part of the period since the beginning of the Christian era, and it is within this relatively short period that much the greater part of the consumption, destruction, and waste of the valuable and most essential resources have occurred.

I believe I am correct in stating that the most important of all the elements to man, or at least the one that enters the most frequently into his manufacturing and commercial life, is carbon. Nature provided a certain amount of carbon in fixed chemical combinations, as our natural resources, coal and oil, which we have been consuming and wasting in a prodigal manner. The total amount supplied by nature is limited. Our experts now know approximately the amounts we have in stock and how long they will last, for end they surely will.

These two resources are mainly being consumed in the production of what the scientific people call wave motions—light waves or heat waves—both of them essential to our way of living, either for the production of light to our eyes, warmth for our bodies, or heat for our domestic, manufacturing, and transportation uses. There are other and perhaps unavoidable uses for our fixed carbon, as, for instance, a reducing agent in metallurgy, the making of carbides, for the making of our arc-lamp carbons, etc. For that portion of the carbon consumed in producing wave motion, and it represents a large part of the total, a ready and everlasting substitute is to be found running to waste in all sections of our great country—our natural resource, water.

It has been so willed and provided that men, while consuming the store of fixed carbon provided for them, have learned to produce these all-important wave motions at will from any source of mechanical motion, and by the utilization of our everlasting flow of waters we can readily produce light or heat and conserve the carbon in our coal and oil for those purposes for which we have not, as yet, discovered a substitute.

To attain this desired end we must begin with conservation of our forests in order that we may have this everlasting flow of the water, and the water must be enslaved to do the work that has been borne by our fixed carbons.

In the carrying out of this work a threefold object should be in view—the production of power for railway transportation, manufacturing and electrochemistry, transportation by waterways and irrigation. Such a project carried to completion would usher in the electro-chemical age, and I predict it would receive an enthusiastic reception.

Electrochemistry, in its more modern form and especially as applied to metallurgy, is still young, taking form in 1888 at the time of the beginning of what is now one of our largest electrochemical industries—the manufacture of aluminum by electricity. Within the twenty years since that date, great strides have been made, a number of chemical and metallurgical processes have been converted into electro-chemical and electro-metallurgical ones in a very successful way and to the advantage of the industrial world, while at least five new materials, previously unknown, are now sold in the world's markets, they having been made possible of production by electrochemistry.

Electrochemistry is in fact a creator. It transforms the cheap and perchance useless wastes into products of value. It works either with the silent invisible electric current, or by the stress of heat. It lends itself to the ready adjustment of temperatures from that of the atmosphere to the highest attainable on earth, one in which the metals, rocks, and all things earthly disappear in vapor. It tears asunder the elements as joined by nature and rearranges them under man's guidance. Thus it has made ordinary sand unite with carbon and form the well-known product "carborundum." In another instance it converts "culm"—the waste material of the anthracite coal mines—into graphite of wonderful purity. In another case it has enabled us to extract from sand metallic silicon, a beautiful silver-colored body, which, although very new, has found a place in our arts and manufactures. As another example, it fuses in the electric furnace the soft amorphous bauxite into a condition suitable for use as an abrasive and refractory material and known as "alundum." And in still another case lime and carbon are made to unite in the electric furnace to form the valuable product, carbide of calcium, now well-known as the source from which our familiar acetylene light is obtained. In this last mentioned example, the world is not only furnished a new and convenient light, but with greater economy of our natural resources. And all this without calling upon our exhaustible natural resources, but by the utilization of the energy of a waterfall.

Electrochemists are now earnestly at work on problems of even greater magnitude than any I have mentioned, as, for instance, the electro-metallurgy of iron and steel, and the fixation of the nitrogen of the air. The commercial fixation of nitrogen gives us a ready and inexhaustible source from which to draw the world's future supply of fertilizer, thus averting the great calamity that has stood specter-like before us—the exhaustion of the earth's fertility. The commercial fixation of nitrogen is now being carried out in Norway, where cheap and abundant electric power can be had. Indeed, Europe is now preparing to use 400,000 horsepower, developed by water, in this line of manufacture, and not to be outclassed, plans are now about perfected to build a very large plant in America, not, however, within the United States, but in Canada at Niagara Falls, where power is more abundant and cheaper than on our side of the cataract, and even then it is twice as costly as in Norway.

Electrochemistry is a power consumer. It requires not only much power, but cheap power. The first hydro-electric power plant of considerable magnitude in this country was put into operation at Niagara Falls in the fall of 1895, since which date quite an electrochemical center has sprung up at that point, and there is now approximately 125,000 horsepower being utilized in the work of producing phosphorus, carbide of calcium, alumdum, caustic alkali, bleaching powder, metallic sodium, aluminum, metallic silicon, carborundum, artificial graphite, chlorate of potash, and other products, the united values of their annual production amounting to many millions of dollars. These Niagara Falls products may, to the great industrial world, seem small, but let me impress on you that they have been developed within thirteen years, that they cover a varied field and they are but a promise of the future development when we have cheap power, they being produced with power costing three to four times the price of similar power in Norway. And when it be remembered that the conservation of the water in Norway is in the interest of power only, we may hope for much when the expenses are carried by power, transportation and irrigation.

To the optimistic electrochemist, it seems possible for his profession to transform many of the chemical and all or practically all of the present metallurgical processes into electrochemical and electrometallurgical ones, and to vastly extend the list of products employed by the industrial world, thereby conserving our fuels by the utilization of water power and conserving our natural minerals by the substitution of artificial ones.

In order that we may obtain the benefits possible of being derived from electrochemistry, it is essential that the art be not crippled by having our natural resources—the water powers and minerals needed by the art—monopolized and held in the selfish interests of a few. The remarkable progress we have been making has been due, to a large extent, to the inducements held out by our beneficent and more or less efficient patent laws, in rewards to the inventor for his labors. A private monopoly is guaranteed him, covering a period of seventeen years, in return for original work he has accurately described to the public, and at the termination of this monopoly, he is presumably, well on the road to permanent success, and decidedly in advance of any possible competitors; still there are men, and particularly those who have taken over the interests of the inventor, who would perpetuate this original monopoly by laying hands on the natural resources of the country that are vital to the inventor's methods or processes, and by monopolizing them prevent others from competing by later and even more efficient processes, and thus they thrive at the expense of their fellow men, at the same time largely defeating the intent of the contract between the inventor and the Government, as contained in the Letters Patent.

In conclusion, I would say no one is, probably, more keenly alive to the possible advantages that should accrue to the world, from this great conservation movement, than the electrochemist, nor should any other profession render more valuable services, following as he will the hydraulic and electrical engineers and putting to work the power they develop for the better conservation of our natural resources.

MR. E. W. WICKEY, REPRESENTING THE FARMERS' NATIONAL CONGRESS.

Mr. WICKEY. Mr. Chairman and gentlemen, I would feel indeed a very weak representative of the great producing class of this country did I not take advantage of this opportunity to assure this convention that you have the hearty cooperation and sympathy of the farmers of this country.

The day of the bewhiskered farmer is passed, as he has been represented in the press up to recent times. The farmer of this country is no longer the man who buys the gold bricks. They are now sold to the man on Wall Street. The farmer of this country is a man to-day who is progressive; one of the most progressive of this age. No great movement of this country has succeeded unless it has been endorsed by the farming class.

It has been suggested here by the governors that there is no North, no South. I want to say to you that the Farmers' National Congress, which I have the honor to represent, was the first national organization in this country to begin to wipe out sectional lines. It was organized by the planters of the South and the farmers of the North, and our officers have alternated between the different sections of the country. We meet one year in the North and the next year in the South, the third year in the West, and the fourth year in the East. Our last session of this year was at Madison, Wis. The committee to-day decided to accept the invitation of North Carolina, and we will meet next year in the city of Raleigh.

We were recognized by both the presidential candidates of the two dominant parties, and Mr. Bryan and Mr. Taft addressed our congress this fall, and we have reasonable assurance that Mr. Taft, as President of the United States, will address our congress when we meet next year.

The farmer is coming to his own. He is being recognized as a power in this land. We no longer think in dollars; we think in hundreds of thousands, as does the banker. The expenditure of millions of dollars in improvement of our natural waterways is no longer alarming to us. The products of the fowls of our farms would improve all the waterways of the land and provide all the money that the National Rivers and Harbors Congress is asking the Congress of the United States to appropriate. The hens of our country would furnish these $500,000,000 in one year and leave enough over to replace the money, Mr. Chairman, that has been spent up to this time on the Panama Canal!

I say to you that the farmer is coming to his own. I want to say that this is largely due to the chairman of this conservation commission and to the President of the United States and to our many great men who are recognizing to-day the power of the farmer. We do not say much. We are not long-winded, but back in our own districts the Congressmen of the United States are beginning to recognize that we speak at the ballot box, and we do not do much kicking; but the man to-day who fails to pass progressive legislation demanded by the farmer soon finds his place at home and not in Congress.

I say to you in conclusion, and repeat it emphatically, that the farmers of the country are in favor of this great movement for the conservation and development of our natural resources. We believe in the development of our waterways. We to-day are spending money for automobiles, for pianos, for improved heating appliances in our houses, for bath rooms, and all of these luxuries of life. We are keeping our money back in our home towns and not sending it to Wall street. Gentlemen, when you want to accomplish the big things, remember the farmer. We are with you on this proposition, and we care not how it is carried out, so the policy and plan is an honest one, as we believe it will be if left to the President of the United States, as has been suggested here. I thank you.

MR. BERNARD N. BAKER, CHAIRMAN OF THE MARYLAND STATE CONSERVATION COMMISSION.

I have listened with great interest to all that has been said at this meeting, and I would like to add, as the representative of Governor Crothers, of the State of Maryland (at the same time expressing to you his regrets that he is not able to be present), that you can count upon the hearty cooperation of our State in the magnificent work you are doing. We would like to do our part, and stand ready to do what we can. Maryland occupies a unique position, at least in forestry, as, I think, it has a larger forest area, in proportion to the total area, than most of the older States. It also has but few water courses that have not already been developed in the way of their powers. If you could conserve to us our terrapin and canvas-back duck you would give a lasting blessing to all our citizens. But this, unfortunately, you can not do.

It has occurred to us that possibly we might be of more assistance in trying to forward the educational features of this great work, and with this object in view, I would most respectfully ask of this commission the consideration and adoption of the following resolution:

"*Resolved*, That a committee of five be appointed by the chairman to consider and report the best way to place before the boys and girls of our country, by educational methods, the necessity for the conservation of our national resources."

I was very much interested in hearing from our friends of the great men of this country—Washington, Jefferson, Lincoln, and Roosevelt. Where are the future great men of our country except among the boys of our schools to-day?

Whatever practical measures be inaugurated in the conservation of national resources, there will be no particular effect save as popular support, which is sincere and intelligent, is secured for such measures. Opposition to practical measures will arise, if any, from those who would gain personally by the exploitation of these national resources. Those who will gain especially by their preservation will be the men and women of future generations; that is, those who are boys and girls at the present time. If firm and intelligent support for practical measures can be secured from these boys and girls, and from them as they grow to manhood and womanhood, by enlightening them as to the purposes of the commission, and awakening their sense of obligation to the nation, then a permanent work can be accomplished. The high schools of the country are becoming very powerful in their influence over their young people, and explanations illustrated by lantern slides showing the national resources and explaining the necessity for their preservation and the practical measures therefor, can be made for these high schools throughout the length and breadth of the country, winning the active sympathy and support of their students. Emphasis can be laid upon the duty of these young men and young women to take personal interest in and to exert themselves in an honorable way toward the enforcement of whatever laws may be passed for the preservation of these national resources. The photographs taken by the government departments will be ample in many ways for the purposes of these illustrated lectures for high schools. The necessity for replanting forests, for preventing pollution of streams, for retarding exhaustion of minerals and prevention of waste, and the success of other countries in such matters can be explained from photographs. The important work already inaugurated by the Department of Agriculture, looking toward the importation of the most important seeds for utilization of the varied soils and climates, can be dwelt upon. The work of experiment stations and agricultural colleges in the improvement of methods of farming and gardening can be noted. The appeal to the high-school boys and girls for cooperation with the Commission in its important work can be made overwhelmingly convincing, and can be laid upon them as a matter of patriotism that they be energetic and wide awake in their support of the cause. It can be made a duty that they take their part in the campaign for national thrift, and it can be shown clearly that national thrift and personal thrift are but one and the same thing.

The practicability of such an educational campaign as outlined is apparent, if one considers the high-school organization. Most high schools have large assembly halls, equipped with electric lanterns, and are in the habit of having general lectures of educational value. A proposal that an illustrated lecture on national thrift and the preservation of national resources be given would probably be accepted by the great majority of the high schools of the country. That such a lecture could be made intensely interesting and effective in its appeal to the boys and girls seems quite certain, in view of the natural personal interest which could be aroused.

A second gain from such an illustrated lecture would be the arousing of interest in country life as contrasted with city life. A portion of the lecture could be devoted to the explanation to city high-school boys and girls of the great opportunities open to many of them, if they would but leave the great cities and devote themselves to country enterprises. Assistance thus could be rendered in the campaign for the prevention of congestion in our cities. The agricultural high schools throughout the country would welcome assistance in their efforts to keep the country boys and girls on the farms.

Inasmuch as sincere patriotism lies at the foundation of the work of this commission, and the effort is to establish practices in the conservation of national resources which will benefit future generations, it is clearly wise to enlighten the high-school boys and girls on this whole matter, since they are the ones who, as men and women grown, will profit by the policy, and upon whom will rest the responsibility for its enforcement and continuance.

Many of us here to-day are men, who, in the natural course of events will not personally enjoy these benefits; the boy and girl to-day in our schools will. Let us show them what we are trying to do for their benefit, and secure their hearty sympathy and cooperation in our work.

MR. HENRY A. BARKER, CHAIRMAN OF THE RHODE ISLAND STATE CONSERVATION COMMISSION.

Rhode Island, though the smallest in her area, is not the least among the United States in her recognition of the great doctrine of conservation. Always has she been foremost in her support of new methods and new principles, destined to promote advancement in the course of civilization. Traditionally she has held up the beacon light, guiding the world toward constitutional government and to the precious doctrine of religious liberty. The first of all communities to formally declare herself as a sovereign State; the first among the American colonies to back up her asserted principles by force of arms.

The name of Rhode Island is written large in the victory of the emancipation of mankind.

Rhode Island, therefore, may not consistently stay out of the procession now marching onward toward conservation and national development, nor can it occupy a rear rank in a movement so enormously significant in its effect upon the welfare of the nation through all the years to come—a movement mightier than most men now foresee—mightier, perhaps, than any man may dream.

Rhode Island, which has been first in war and first in her assertion of the sovereign right of man to constitutional government, must rejoice in her opportunity to be among the first in a splendid enterprise of peace.

DR. CYRIL C. HOPKINS, OF THE UNIVERSITY OF ILLINOIS AND MEMBER OF THE ILLINOIS STATE CONSERVATION COMMISSION.

I beg to urge upon this conference that larger consideration be given to the preservation of the fertility of the common American soil. You have heard it stated here that by means of irrigation it is possible to reclaim hundreds of thousands of acres of land in the arid or semiarid States. It can also be said with equal truth and it should be said with greater emphasis that under our most common farm practice we are reducing the fertility of not merely hundreds of thousands of acres, but of the great body of American farm lands, upon the preservation of which depends absolutely the prosperity of the United States.

Within a hundred miles of the spot where the first permanent English settlement was made in our country, you can to-day buy hundreds of thousands of acres of arable land for $10 an acre, land that was once valued at $50 an acre, and would now be worth $100 an acre if its fertility had been maintained. And I do not include in this statement any reference to lands that have seriously suffered from soil erosion, but I refer only to great areas of nearly level or gently undulating farm lands whose productive power has been almost destroyed by a hundred years or more of common cultivation by American farmers.

The great material problem of the United States is not in the development of the waterways, not in the preservation of forests, and not in the conservation of our coal and iron, important as these all are, but the problem that is vastly greater than all of these is to bring about the adoption of systems of farming that will maintain or increase the productive power of American soils.

We must not deceive ourselves with general statistics which show some increase in average crop yields in some States. Thus, in my own State of Illinois the average yield of corn has increased in the past ten years, but does this prove that Illinois soils are growing richer? No. Let me tell you that during the past ten years the annual corn area of Illinois has increased from 7,000,000 to 9,000,000 acres, and the added 2,000,000 acres are the richest black soil of the State, reclaimed by dredge ditching and tile drainage, while the 7,000,000 acres are producing smaller crops than ten years ago.

The practice of the present art of agriculture tends toward land ruin. If any of you know anything of American agriculture, you know that as a general rule old land is poorer than new land. Therein lies the fact that points toward future poverty for our children. The United States is one of the great agricultural countries, and without agriculture America would be nothing. Without agriculture our coal and iron would remain in the earth, our forests would be uncut, our factories, railroads, and waterways would be abandoned, and our cities depopulated.

If the art of agriculture has reduced the productive power of American soil, then the science of agriculture must restore it; and the key to the problem for our most common agricultural land is the element phosphorus. Phosphorus is the only element of value contained in the mineral called phosphate. There are three elements of plant food that have recognized market values—nitrogen, phosphorus, and potassium—and the inventory of our natural resources must include the supply of each of these three elements.

The nitrogen can be gotten from the air, not only without expense, but with profit in the getting, because such crops as clover and alfalfa, which by means of symbiotic bacteria have power to utilize atmospheric nitrogen, are valuable crops to raise for their own sake, and where these are plowed under liberally, either directly or in manure, nitrogen is thus supplied for the production of any other crop.

Potassium is one of the abundant elements in the earth's crust, and consequently in all normal soils. Thus, several hundred analyses by the Illinois Experiment Station have shown that the average corn-belt land contains sufficient potassium in the plowed soil for a hundred bushels of corn per acre every year for as long as the time since Christ walked among men—or sufficient potassium for the average corn yield of the United States every year for as long as since Adam began to till the soil.

One hundred bushels of corn contains 19 pounds of potassium and 17 pounds of phosphorus; and, while the average crust of the earth contains 2½ per cent of potassium, it contains only one-tenth of 1 per cent of phosphorus; and the most common agricultural lands of the United States contain in the plowed soil no more total phosphorus than would be required for a crop of a hundred bushels of corn per acre during the full life of one man.

For the adoption of systems of permanent agriculture under which our common lands shall grow better instead of poorer, the nitrogen problem is to secure it from the absolutely inexhaustible supply in the air, and the potassium problem is to draw it as rapidly as necessary from the practically inexhaustible supply in the soil, while the phosphorus problem is to get all we can and keep all we get.

But what are we doing? We are exporting every year for less than $6,000,000 sufficient phosphorus for the production of $600,000,000 worth of corn, while the scarcity of the element already limits the yield of corn on the commonest corn-belt land.

I close with a single illustration to show the possibility of increasing the productive power of the land with proper treatment and the certainty of soil depletion even under a good crop rotation without the addition of plant food.

For sixty years at Rothamsted, England, the oldest agricultural experiment station in the world, a four-year rotation of turnips, barley, clover (or beans), and wheat has been grown on Agdell field, where the soil is of normal composition. There are three sections in this field; no plant food has been applied to one, minerals, including phosphorus, to the second, and the same with nitrogen added to the third.

As an average of the last twenty years, corresponding to the average yield just fifty years from the beginning of the experiments, the following results were obtained:

Average crop yields per acre in Rothamsted, four-years' rotation, after fifty years.

Soil treatment.	None.	Minerals.	Minerals and nitrogen.
Turnips ....pounds..	963.0	25,278.0	40,947.0
Barley ....bushels..	13.7	22.2	29.2
Clover ....pounds..	773.0	3,898.0	3,450.0
Beans........bushels..	15.9	28.3	19.6
Wheat ....do....	24.3	38.4	36.4

Beans were grown where clover failed.

When the American farmer had depleted most of the lands of the Eastern States he moved into the Central States, and he is practicing the same ruinous systems there, and if these systems are continued, wherewithal shall America feed her own people a few years hence?

I say to you famine in America is easily possible. There may be no need for sensation, but there is need for sense.

I say to you if we are ever to adopt systems of permanent agriculture in America it must be done while we are prosperous, for an impoverished people is at once helpless and soon ignorant. Only the prosperous can afford education. It is impossible for a poor farmer on a poor farm to invest in the permanent improvement of his land if he has nothing to invest—if it requires every dollar he can secure from the sale of every salable product to support his family and pay his taxes.

Whenever the hundreds of thousands of acres of level or gently undulating depleted or abandoned farm lands of New York and old Virginia are redeemed and made equal to the newer lands of the Central West, which are now in their prime, paying good interest on $200 an acre, then, and not till then, can there be any other material problem of the United States that compares with this in reference to the future welfare of America.

MR. EDWARD R. TAYLOR, CHAIRMAN OF THE CONSERVATION COMMITTEE OF THE AMERICAN ELECTROCHEMICAL SOCIETY.

Mr. Chairman, ladies, and gentlemen, I address you as chairman of the conservation committee of the American Electrochemical Society.

In the wastes referred to in the introductory part of the very able report of the conservation committee to President Roosevelt I wish had been included the waste of running water. This waste in the State of Alabama alone was admirably shown by Mr. Lay yesterday to be equivalent to the running over a precipice of 11,000,000 tons of coal, and if saved and applied as it should be is capable of saving that much coal to the State, at the same time making navigable several of its rivers the year round.

The great bulk of our people in this great country live on the most valuable land near the level of the sea, and very few such realize the immense possibilities for water storage by lakes and reservoirs in the hill country.

About two weeks ago I visited a farm on the headwaters of the Delaware River through which runs a brook from which the farmer derives 25 horsepower and lights his building and house with the electricity generated therefrom. He could also do the cooking, heating, and lots of other things about his place with the same power. This is now the only power developed on that brook, which, he told me, formerly ran 89 sawmills. If each of these sites could develop 25 horsepower, which is a fair assumption, that little brook alone represents a waste of 2,206 horsepower and represents the running to waste of 26,460 tons of coal; and yet those very families are drawing coal from the railroad 5 miles away and letting all of this power go to waste.

But by storage reservoirs in this same hill country the above-estimated power could easily be doubled or trebled, or made even five times as much. Multitudes of other streams in the same vicinity could be similarly treated and the electricity generated at every site ted to a common center, every farmer and resident supplied with all he wants to use and the remainder used to run electric cars for their benefit and for lighting and heating the buildings in the near-by towns and for manufactories that could be built up, or sent on high-tension wires to large cities within reach. From 100,000 to 300,000 horsepower could be developed near the center where this creek joins the Delaware River, the buying of coal practically cut off, and new pleasure added to life for the inhabitants; at the same time flood waters restrained from spoiling the more valuable land near the sea and navigation improved. This farm is about 1,600 feet above sea level, and every cubic foot of water per minute from that level, passed properly through water wheels to the sea, would represent 3 horsepower or the saving of 36 tons of coal per year. May each State develop one or two such centers of power as object lessons and to show what can be done. Do not say it is small; it is big when we aggregate the possibility.

This is by no means an exceptional possibility, but a typical illustration of multitudes of opportunities in the hill country throughout our broad land, and, if generally so used, would develop millions of horsepower, make year-through navigable rivers and reduce to minimum flood damages. Every lowland State in the Union is directly interested in the remote hill States that are the source of these mighty rivers, and should insist that water that can be impounded into lakes there and converted into power of great value shall not run to waste and overflow their valuable lands. Truly our brotherhood is wide and large. Therefore even this is a work for the whole country, and the General Government should aid in making some illustrative developments on small streams. "Look not every man on his own things, but every man also on the things of others."

But I have a much larger subject to speak of. The level of Lake Erie is 565 feet higher than the Hudson River at Albany, and is downhill all the way except a sag of about 20 feet between a little east of Rochester and a little west of Rome. This can be overcome either by raising the level of Cauga Lake and changing the course of the canal to higher levels than now contemplated or cutting down the Rome level to make a complete lock down ship and power canal from Lake Erie to the Hudson River.

New York State is committed to a barge canal which takes no cognizance of power developed in this electrical age even for the haulage of its own boats.

A ship and power canal thus constructed through the State of New York is estimated to be worth, for power alone, by Engineer McClintock, at $500,000,000, and he made earnest protest against committing the State to the barge canal it is now building. Niagara Falls is the seat of power that it is to-day because of the utilization of about 140 feet head of water. But what would it mean to utilize 500 feet head of water distributed through the grand State of New York, and three-fifths of that within 175 miles of New York City, with a harbor for large vessels all along the way, and the conversion of western wheat in transit into flour, and the manufacture of crude materials into higher values. The commerce of the Great Lakes is stupendous and should be continuous to the sea, and is a suitable work for our National Government to make possible. For navigation purposes a canal through there can be used but about eight months per year, but its power can be used the whole year through. Selfish interests in Buffalo and New York City committed our State to a barge canal exclusively for navigation; but even so, our great Inland Waterways Commission should step in and right the wrong and give us a ship and power canal commensurate with its great earning power, and the stupendous transportation interests of the West crying for an adequate outlet to the sea, a thing they are bound to have.

MR. JOHN B. ATKINSON, OF KENTUCKY.

Mr. Chairman and gentlemen of the Conservation Conference: As a representative of Governor Willson, of Kentucky, who greatly regrets his inability to be present on this occasion, I can tell this meeting that much interest in the conservation of the forests is being manifested in my State.

Women's clubs have become greatly interested, and good work is being done by them. It was my good fortune to address recently the Alumnæ Club of the Girls' High School, of Louisville, on "How we plant trees in Kentucky," illustrating with photographs and transparencies the young planted forests at different ages. The ladies of the club will give talks on practical forestry in all the public schools of the city, and illustrate with photographs what can be done in the way of making new forests, thus reaching 27,000 school children in one city alone.

Women's clubs in many cities of the State are asking information and pictures for the use of the clubs and schools. When the women take up any great subject, we all know that great good will follow.

Nor are the women and children alone interested. Large corporations owning forests and coal properties are gathering information, and slowly, perhaps, imbibing the fact that there is money saved in the more careful cutting of timber. One large company has planted this autumn and winter 1,000 bushels of walnuts (over 300,000 nuts) on 1,000 acres of woodland that had been partially cut off, and is inclosing the tract with a fence to keep off cattle and other stock. The railroad companies are planting trees in large numbers also.

Kentucky was one of the best timbered States in the Union, and still has more than half its area covered by forests in various stages of preservation and offers at this time an opportunity that few States possess of rebuilding them to a high condition of efficiency and perpetuity.

A close partnership exists between the forests and the mines. Timber is as necessary in mining as is labor. Hence the mining man is especially interested in having perpetual forests. It now takes the annual growth of at least 6,000 acres of forest to raise 1,000,000 tons of coal in Kentucky.

The mining company with which I am interested began planting trees twenty years ago. It came into possession of many acres of worn-out farm lands as well as of large areas of forest. Corn and tobacco had been the principal crops grown by the farmers and when the soil became so poor it would not grow corn the fields were turned out and new ones made from the forest; the trees girdled and finally burned and a new start made with tobacco and corn.

By judicious fertilization and cultivation 2,000 acres of the worn-out lands were brought back to fertility and now produce excellent crops. It had become evident to the management of the property that judicious cutting of the timber for mining purposes was necessary to perpetuate the forests, and it was also determined to plant the vacant cleared land with trees. The black walnut was selected, because of the value of the wood and the readiness of planting. The ground was prepared as for corn, and the walnut with the hull on was planted in the autumn when the nuts matured. The nuts were planted 4′ by 4′ or 2,722 nuts to the acre, being covered by 1 inch of soil. The young forest was cultivated the same as corn for three or four years, and then sown down with blue grass. The spacing of the walnuts 4′ by 4′ was to get a growth upward and also save pruning; the trees to be thinned out from time to time, which was done by cutting down the tree, it being found that it was not profitable to transplant. Far better to plant a nut where a tree was desired. Blue grass always grows under walnut trees, and when the young walnut forest gets to be 10 or 12 years old the trees are high enough and strong enough not to be injured by cattle grazing, and we have walnut trees, blue grass and Jersey cattle growing together. While this is not the rule of forestry to have cattle and trees together, the walnut forest may be considered the exception.

When we began planting trees twenty years ago we had little knowledge of the ages of forest trees, or how long it took nature to produce a forest. A study of stumps was taken up, and the ages of the various trees cut for mining purposes determined. From the facts collected during the twenty years past is made a table of the time it takes certain trees in Kentucky to grow to a diameter at the stump of 12 inches. This is not an infallible table, but is based on actual tree growth as observed in the forests, and has no reference to isolated growth or unusual conditions.

The pin oak will grow 12 inches diameter in forty years.
Black locust will grow 12 inches diameter in forty-five years.
Tulip will grow 12 inches diameter in fifty years.
Black oak will grow 12 inches diameter in fifty years.
Black walnut will grow 12 inches diameter in fifty-six years.
Texas red oak will grow 12 inches diameter in fifty-eight years.
Sweet gum will grow 12 inches diameter in sixty-two years.
Ash will grow 12 inches diameter in seventy-two years.
Hickories will grow 12 inches diameter in ninety years.
White oak will grow 12 inches diameter in one hundred years.

The trees so far planted for forests are the black locust (Robinia), catalpa speciosa, walnut, and tulip (Liriodendron). Since 1887 this company has planted over one million black walnuts on 170 acres of farm land, and in vacant places in the forest. Since 1905 we have planted 110,000 black locusts on 162 acres of land. The seedlings are planted 8 by 8 feet, the same as locusts. We have planted 20 acres of tulip trees (Liriodendron), or 435 trees to the acre 10 by 10 feet. All the young forests are cultivated for three or four years and are always under fence. This company will plant in the spring of 1909 over 60,000 catalpas and 40,000 locusts. It has already planted this year 100 bushels of walnuts (30,000 nuts) in vacant places in the forests.

The question arises, How can landowners be induced to plant trees?

To me the answer is, take off all taxes on land growing young forests, and when productive, tax the product only. I believe this same rule should apply to all forests.

If the legislature of a Commonwealth can protect quails and rabbits with its game laws, it surely can protect the trees. If the owners of forest lands in Kentucky could be induced, or compelled, to fence them against all kinds of stock, and then cut healthy trees, not less than 16 inches in diameter, there would be no question of the perpetuity of its forests.

DR. GEORGE F. KUNZ, PRESIDENT OF THE AMERICAN SCENIC AND HISTORIC PRESERVATION SOCIETY.

The beautifying of the country village or of the farm; the utilizing of the land by the roadside, in place of allowing it to degenerate into a weed bed; the building of proper roads, and the fencing in of attractive points, will do much to keep the young man of the farm where he belongs, where he will be most happy, and where his labor will increase the annual sum of our agricultural production, the greatest asset of the nation. To attain this end there should be some concerted action on the part of the National Government, through the Department of Agriculture, cooperating with the Grangers, the board of state fairs, the county fairs, the Epworth League, and the many organizations which are working to make farm life attractive, and which by their efforts have raised the intellectual level of the farmer, stimulated his interest, and increased the productiveness of his labor. Either the Department of Agriculture, or the National Conservation Commission can easily come into direct contact with all these organizations.

For the realization of these aims, brief pamphlets, or, better still, a few pages issued monthly—to be so short that they may be read at the meeting of every Grange or public gathering of farmers, and to treat, one month in advance of the planting time, of the care of stock, new fertilizers, farm products likely to be in demand, and the abundance or shortage of crops in the various parts of the country—will do more good than millions of scientific and complex works that only specialists can understand, and yet will lead to an appreciation of the latter in the course of time. This will prepare the way for the elaboration of some system whereby every village throughout the entire land will be enabled to set aside a number of acres for a village park or green, the amount of land to be dedicated to conform to the resources of the village. It frequently happens that a most unproductive tract is the most beautiful from a scenic point of view. In proximity could be located the village cemetery; and if such a tract were beautified and planted with typical trees, supplied either by the Nation or the State, or else by the local committees or private enterprise, it would do much to educate those who lack the facilities enjoyed in cities.

In addition to this certain flower seeds and plants could be furnished and—what would also be of great value—a small tract could be assigned for the children to cultivate as a garden. Thus, in a community where there are thousands of acres of land, 10, 20, or 50 acres could be set aside for the furtherance of village improvements, and parcels of land suitable for the purpose could often be obtained from town-tax sales, as a gift or as a united contribution. There should be the wood lot for the poor and needy; the playground and other places for recreation; the small botanic garden, with its typical trees and plants; and the small experimental garden for the children, where they could be taught the principles of gardening and at the same time have the opportunity to earn some pennies for pocket money, something a farmer spares with such difficulty and often so grudgingly that the child becomes only too willing to leave home and try his fortune elsewhere. Besides this, however, the children should be taught to suppress the weeds along the roads so that grass or productive plants may replace the wild luxuriance of unsightly weeds. The children should also be encouraged to gather up the stones from the highways, making the roads more sightly, easier to ride over, and also safer, thus saving many lives in the course of the year.

But we must not forget the power of historic associations in fostering interest in the town or village. Gatherings should be held on historic days, addresses delivered by the best talent the town affords, and the local children should take part. There should be placed in every part, or reservation, or village tract, a signboard of wood or of stone, bearing the date of the settlement of the district, and the record of any historic happenings connected with it, and also a simple map, showing its distance from other neighboring places. If there are any prominent historic points within the limits of the village or country, such as old milestones or houses of notable people, these should be marked in a very simple manner on tablets made of terra cotta, for instance, which could be manufactured at the nominal cost of a few dollars each. Furthermore, as an object lesson in road building, it might be possible to have specimens in the shape of small roads, or a road running around the border of the village park, so constructed as to illustrate the various types of road building best adapted to the region, using only the materials at hand for their construction and thus showing the extent of the local resources. The tract could also be fenced with various forms of fencing, from the most inexpensive to the more costly, so as to lend variety to the fenced-in sections, and at the same time educate the people, from childhood up, in the best and simplest forms of making a fence. If the reservations should be situated at county lines, or even village lines, pillars of history could be erected, stating the history of the place as briefly as possible. This would not only serve to educate those who live in the various communities, but those who pass through could not fail to find interest in noting facts that are often either forgotten or ignored. Incidentally, if all these suggestions are acted upon, the land and taxable value will be increased.

Last but not least, if there are any water supplies, such as springs and brooks in the vicinity, the proper establishment of water troughs or of fountains along the road would greatly benefit the passer-by as well as the resident, and would frequently help to educate the children as to the importance of conserving a good water supply, a consideration that was fully recognized two thousand years ago in Roman times, and caused the erection of those splendid aqueducts which reflect such credit upon ancient Roman civilization.

HON. GEORGE W. KOINER, MEMBER OF THE VIRGINIA STATE CONSERVATION COMMISSION AND STATE COMMISSIONER OF AGRICULTURE.

Mr. KOINER. I present here the statement promised by Mr. Rosewell Page in his address as the representative of the governor of Virginia.[a]

The area of Virginia is 40,125 square miles (27,168,000 acres), of which 2,325 square miles are water. Its greatest dimensions are from the Atlantic southwesterly to Kentucky, 476 miles; the longest line north and south is 192 miles. The boundary lines of the State aggregate about 1,400 miles.

The estimated population in 1908 is 2,253,284, an increase of 5.3 per cent over that of 1900. In 1906 the estimated population of the leading cities was: Richmond, 87,246; Norfolk, 66,931; Newport News, 28,749; Lynchburg, 22,850. The colored population of Virginia has for years been rapidly decreasing owing to migrations of negroes to the north and to the south. In 1900 the foreign population was only 19,461.

The surface of the State is diversified, rising in a series of six terraces from the southeast to the northwest. The tidewater Virginia is penetrated by the Chesapeake Bay, and has a shore line of 1,500 miles. The middle section of the State is an undulating plain with an elevation of from 200 to 600 feet and extends to the foothills of the Appalachian Range. The western part of the State is mountainous, the Blue Ridge and the Piedmont ranges crossing the State in a southwesterly direction, and the Alleghanys forming the boundary line of West Virginia. The valley section is a broad belt of rolling country, diversified by hills, ridges, and river valleys, lying between the Blue Ridge and the Alleghany Mountains. This region contains the sources of the Shenandoah, Roanoke, James, Kanawha, and Holston rivers. The most important rivers are the Potomac, separating Virginia from Maryland, navigable as far as Washington, and the James, with its extensive network of tributaries, navigable to Richmond. Both of these rivers empty into Chesapeake Bay, as do the York River and the Rappahannock. Along the mouths of these rivers and large portions of the bay are the State's priceless oysterlands. About the heads of these streams is her wealth of forest and water power. Lake Drummond, in the Dismal Swamp, is the only lake in the State.

Archean granites, syenites, metamorphic rocks of a greenish hue, and gneiss form the oldest geological deposits in Virginia. These stratifications are found in the Piedmont plain. The coastal plain to the eastward shows Tertiary and Quaternary deposits, indicated by the presence of sand, gravel, and clay. Coal deposits in several counties of the State, located east of the Piedmont plain, are Triassic in origin. Paleozoic strata predominate in the Appalachian plateau. Cambrian deposits are found in the Blue Ridge. Devonian sandstones and limestones appear in other ranges. The valleys of Virginia are paved with limestone of the Silurian system. Conspicuous among the remarkable geological features of the State are the Natural Bridge, the caverns of Luray, and Weyers Cave.

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[a] Page 196.

The following mineral products are found in Virginia: Asbestos, barytes, clay, coal, cobalt, copper, gold, granite, graphite, gypsum, iron, kaolin, limestone, manganite, marble, marl, mica, mineral waters, nickel, ocher, pyrites, salt, sandstone, and zinc. The most important are coal, iron, granite, clay, and mineral waters. The bituminous coal output of Virginia in 1904 exceeded 3,500,000 tons. Coal mining at present is chiefly carried on in Tazewell, Buchanan, Dickenson, and Wise counties. The State's product of brown hematite iron ore in 1904 exceeded 500,000 long tons. Iron ore is plentiful in the Piedmont and Appalachian regions. The value of the granite output in 1904 exceeded $500,000; limestone, $400,000. The building stone deposits are widely distributed. The value of clay products in brick and tile in 1904 exceeded $1,500,000. Manganese is found in the Shenandoah Valley. Gold is mined in Louisa and Spottsylvania counties. Saltville is the center of the salt producing industry. The annual output of coke is 700,000 tons; Portland cement, 60,000 barrels; gypsum, 12,000 short tons; mineral waters, 1,000,000 gallons; slate value, $200,000. The total mineral output for 1908 was about $35,000,000.

East of the Blue Ridge the climate is mild or temperately warm, with mean temperature in January of 37° and 77° in July. In winter the minimum temperature seldom exceeds 10°; the maximum in summer is 102°, but generally about 100°. The climate is dry and salubrious. The summers west of the Blue Ridge are cool, and the winter, particularly in the mountains, cold, the temperature falling, as at Staunton, in the great valley, to 8° below zero. The rainfall is evenly distributed and sufficient for agriculture. In the central portion the average is 48 inches; in the great valley it is 38 inches.

In tidewater Virginia the soil is light alluvial, but the mildness of the climate favors garden farming, which is largely followed. Middle Virginia has a subsoil of dark red or yellow clay with rich loams, and along the streams decomposed rock. In the Piedmont division the soils of decomposed sandstone are more fertile than the yellow and grayish soil. The Blue Ridge region has a soil like that in the Piedmont region, but richer in decomposed rock, and particularly adapted to the culture of rich grasses, vines, and fruits. The limestone soils of the great valley produce large crops of grain and grass.

Virginia has great forests with a variety of timber, including pine, oak, hickory, elm, poplar, willow, beech, birch, walnut, maple, cedar, mulberry, locust, sycamore, juniper, cypress, chestnut, etc.

The farm area of Virginia is about 19,907,883 acres, of which about 9,900,000 acres are improved. The following figures show the yield in 1908: Corn, $30,000,000; wheat, $8,000,000; oats, $1,500,000; hay, $10,000,000; tobacco, $8,000,000; potatoes $3,200,000; peanuts, $2,500,000; all trucks, $12,500,000; orchard fruit, $5,000,000; dairy products, $7,000,000; forest products, $10,000,000; miscellaneous crops, $1,300,000; live stock, $70,000,000; total $204,000,000.

The church denominations are: Methodist, Baptist, Presbyterian, Episcopal, Disciples of Christ, Lutheran, Roman Catholic, Dunkards.

The present school system of Virginia, begun in 1870, is under the supervision of a superintendent of public instruction, chosen by the general assembly and the board of education. Separate schools are provided for white and colored children. In 1908 the number of schools were 9,382; pupils, 375,878; teachers, 9,468. Number of state normal schools, 5; high schools with special normal departments, 20; state agricultural colleges, 2; high schools with special agricultural departments, 10. The state and local appropriations for public free schools were $3,519,739.57. Three normal schools for young women, viz: State Female and Normal School, Farmville; State Normal and Industrial School for Women, Fredericksburg; and State Normal and Industrial School for Women, Harrisonburg, Va.

William and Mary College, Williamsburg, founded in 1693, with 20 instructors, 225 students, and 15,000 volumes in library; Washington and Lee University, Lexington, founded 1749, 31 instructors, 500 students, 50,000 volumes in library; University of Virginia, Charlottesville, founded 1819, 83 instructors, 750 students, and 60,000 volumes in library; the Virginia Polytechnic Institute at Blacksburg, and the Virginia Military Institute at Lexington, are great institutions where work of the highest value is being done.

Other colleges are Richmond, at Richmond; Randolph-Macon, at Ashland; Roanoke, at Salem; Virginia Union University, Richmond; Emory and Henry, at Emory; Bridgewater, at Bridgewater; Hampden-Sydney, at Hampden-Sydney; and Fredericksburg, at Fredericksburg. There are women's colleges of high order in Richmond, Lynchburg, and Danville.

The CHAIRMAN. Gentlemen, I desire to express my most heartfelt thanks to all of you who have formed this great movement. Whatever happens here in Washington is of small account unless it is the expression of what happens away from Washington. The center of this conservation movement, in the sense of the active center, is not here in Washington at all, but is scattered all over the country. I want you to appreciate that that is the feeling here. We who are at work under the National Government understand fully that nothing we do is of any consequence except as it meets with the approval of the States and the organizations and citizens of the United States, and just so long as the interest grows and the activity continues in other parts of the country, just so long will the movement succeed, and not otherwise.

Cooperation was the keynote of this meeting, cooperation between the States and the nation, between the States themselves, between the States and the great national organizations, and if this meeting succeeds in establishing, as, since these resolutions passed, I hope and believe it will, a coordinated effort, including all these agencies, directed to one great end, the conservation of our natural resources, it will have done more by itself than all the other things that have ever happened in this movement up to this time. When we get together effectively we shall get together to win. Until we get together effectively, whatever agitation we may have, whatever education we may carry out, will not be brought to the point of action. It is the getting-together side of this movement that impresses me so tremendously at this congress.

Finally, I want to thank you for myself for your kindness to me. I have never supposed that any such kindness as has been exhibited to me during the last two or three days would ever come to my lot. It has come, and I am glad of it, and proud of it. I want every one of you to come to-night to 1615 Rhode Island avenue and see the reason for it—my mother.

Senator **SMOOT**. Mr. Chairman, I believe it would be a good thing to call the attention of the governors here to-day to the fact that there is one class of men which ought to receive our most hearty thanks, for it was that class of men that made it possible to have this inventory taken so completely as it is. They have worked early and late. This work has been done outside of hours with no pay whatever for it, and it would have cost at least half a million dollars if the services had been paid for; not only would it have cost that, but it would have been absolutely impossible to have it within two or three years' time if it had been gathered through any other channel or by any other men.

Mr. Chairman, I wish to offer this motion, that this conference give its most hearty thanks and appreciation to the secretaries of all four of the divisions of the National Conservation Commission, and also to the experts who have worked so hard from all the departments of this Government.

(The motion was unanimously adopted.)

ADJOURNMENT.

The **CHAIRMAN**. Is there any further business to come before this meeting?

Governor **ANSELL**. Mr. Chairman, I move that we do now adjourn sine die.

(Motion carried.)

(Thereupon the joint conference adjourned sine die.)

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60th Congress 2d Session } SENATE { Document No. 676

REPORT OF THE NATIONAL CONSERVATION COMMISSION

WITH ACCOMPANYING PAPERS

FEBRUARY
1909

SPECIAL MESSAGE FROM THE
PRESIDENT OF THE UNITED STATES
TRANSMITTING A REPORT OF THE
NATIONAL CONSERVATION COMMISSION, WITH ACCOMPANYING PAPERS

IN THREE VOLUMES

VOLUME II

EDITED UNDER THE DIRECTION OF THE EXECUTIVE
COMMITTEE BY HENRY GANNETT

WASHINGTON
GOVERNMENT PRINTING OFFICE
1909

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SENATE OF THE UNITED STATES,
February 18, 1909.

Resolved, That the special message from the President of the United States, transmitting a report of the National Conservation Commission, with accompanying papers and illustrations, be printed in full as a document, taking number 676 of the present Congress, the number of the document containing the special message of the President transmitting this report.

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ACCOMPANYING PAPERS

WATERS AND FORESTS

PREFATORY NOTE.

The following papers were prepared by the experts under whose names they appear and who assisted the commission in its labors. These papers form the body of information on which the report of the commission is based and from which the statements of the secretaries have in the main been prepared.

Naturally, these papers, representing as they do the original work of experts along various lines pertaining to the resources of the country, express some diversity in views. Since each opinion is that of an expert, the commission has not deemed it wise to undertake either acceptance or elimination of the views; and has decided, without expressing its own opinion, to leave the experts' views to the test of time as our knowledge extends and becomes more definite.

ESTIMATES OF FUTURE POPULATION.

By Henry Gannett,
United States Geological Survey.

Under normal conditions, the rate of increase of a body of population slowly decreases. Other things being equal, as the density of population increases and as the difficulty of breadwinning becomes greater with diminished opportunity, natural increase and immigration decrease. The rate of increase may, and frequently has been, affected by disturbing factors, causing it to increase temporarily or to decrease more rapidly than normal. As an illustration, the population, increase in numbers, and rates of increase in the United States by decades from 1790 to 1900 are given in the following table:

Year.	Population.	Increase.	Rate of increase.
			Per cent.
1790	3,929,000		
1800	5,308,000	1,379,000	35
1810	7,240,000	1,931,000	36
1820	9,638,000	2,399,000	33
1830	12,866,000	3,228,000	33
1840	17,069,000	4,203,000	33
1850	23,192,000	6,122,000	36
1860	31,443,000	8,251,000	36
1870	38,558,000	7,115,000	23
1880	50,156,000	11,597,000	30
1890	62,622,000	12,466,000	25
1900	75,569,000	12,946,000	21

From 1780 to 1840 the population was little disturbed and immigration was small, and the rate of increase dropped from 35 or 36 per cent to 33 per cent. Between 1840 and 1850 there was a great wave of immigration, which increased in the succeeding decade and raised the rate of increase to 36 per cent. Then came the blighting effects of the civil war; deaths from casualty and diseases and the reduction of births (aided to an uncertain extent by omissions in the census of 1870) reduced the rate in that decade to 23 per cent. Between 1870 and 1880 the country began to recover from the effects of war, and the rate of population increased to 30 per cent. The succeeding decade witnessed a drop of 5 per cent, and the following one of 4 per cent. Thus in 110 years the rate of increase of population has been reduced from 35 to 21 per cent. If normal conditions prevail in the future, it is certain that the rate of increase will continue to diminish until the rate reaches that of the densely populated countries of western Europe—about 10 per cent increase per decade. It will be noted that in the table the numerical increase has been steady excepting for the period between 1860 and 1870.

A great variety of population conditions exists in the United States. There are communities where increase is supplied wholly by immigration; others receive no immigration, but are dependent upon the excess of births over deaths; there are regions where commerce and manufacturing cause dense population; thickly populated farming regions now passing into manufacturing communities; prosperous farming regions; sparsely peopled pastoral lands; and desert wastes with few people. All have different rates of increase, and the figures discussed represent the total of all these different conditions.

Several predictions of our population have been made at various times by different and by more or less complicated and elaborate methods. One or two of these predictions have by accident hit very near the truth, as made known by later censuses, but all have been finally wide of the mark.

A mathematical method which has been employed consists in deducing the equation of the curve which the population has made, beginning with the first census and ending with the latest available, and so projecting this curve into the future. Such a formula expresses past conditions with accuracy, but its application to the future assumes that similar conditions will prevail hereafter, which is extremely unlikely.

A simple method which has been employed is to assume that the numerical increase of each decade will continue the same and be equal to that of the latest decade measured by the census, at present that of 1890 to 1900, when the increase was 13,000,000. It is not probable, however, that the numerical increase will remain stationary, but will increase still more. Great Britain, with 347 inhabitants to a square mile, shows a continual increase in its decennial increment, and other densely populated European countries show the same. Hence, it is believed that such predictions are somewhat too small.

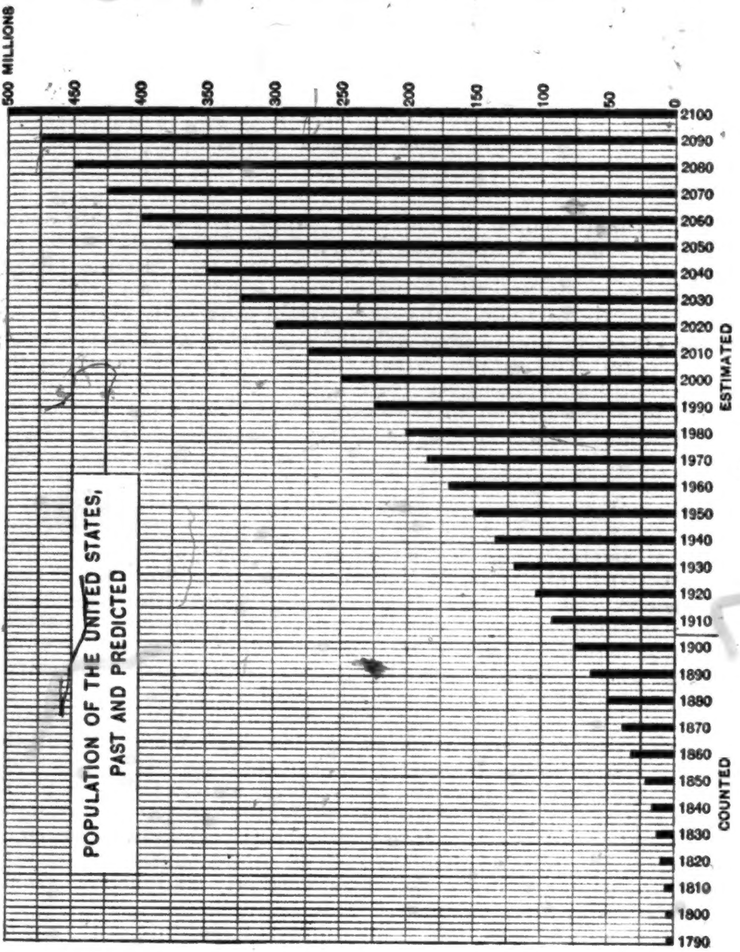
Another simple method assumes that the rate of increase, which was 21 per cent from 1890 to 1900, will decrease by a certain per cent each decade, say 1 per cent, being 20 per cent between 1900 and 1910, etc.

It is probable that for several decades the amount of reduction in the rate of increase will be greater than 1 per cent, and that then the rate of its reduction will be slowly lessened, so that perhaps a century hence, in the year 2000, the rate of increase may be 10 or 11 per cent, but the population will not be as great. As a guess, the population in 2000 may be placed at a figure not very far from 250,000,000, or about midway between the results given by these two methods.

Accepting the above figures, the following table shows by decades the probable population and rates of increase until the year 2000, with the guess extended a century further into the future:

Year.	Population.	Increase.	Year.	Population.	Increase.
		Per cent.			*Per cent.*
1900	76,000,000		2010	274,000,000	10
1910	90,000,000	21	2020	299,000,000	9
1920	104,000,000	16	2030	325,000,000	9
1930	119,000,000	14	2040	350,000,000	8
1940	134,000,000	13	2050	375,000,000	7
1950	150,000,000	12	2060	400,000,000	7
1960	167,000,000	10	2070	425,000,000	6
1970	184,000,000	10	2080	450,000,000	6
1980	202,000,000	10	2090	475,000,000	5
1990	225,000,000	11	2100	500,000,000	5
2000	249,000,000	11			

Thirteen countries of Europe, including all the larger, older, and most densely settled ones, which comprise collectively a population of 260,000,000, show a decennial increase of population in the last decade of 24,400,000. Here is a case approaching parallelism with what the United States may expect to be ninety or one hundred years hence.



DISTRIBUTION OF RAINFALL.

By **Henry Gannett**,
United States Geological Survey.

The ultimate source of our water supply is rainfall, the chief source of which is evaporation from the Pacific Ocean, while secondary sources are the Gulf of Mexico and the Atlantic Ocean. Brought from the Pacific by the westerly winds of the north temperate zone, the moisture in the air is carried eastwardly nearly across the continent in diminishing quantities, varying at different times of the year. The supply in the atmosphere is reenforced in the Mississippi Valley from the Gulf of Mexico, whence it is drawn inland by southerly and southwesterly winds; and again east of the Appalachian Mountains it is reenforced from the Atlantic Ocean, from which it is drawn by easterly winds accompanying cyclonic disturbances.

The areal distribution of the rainfall is in general terms as follows: The precipitation is very heavy upon the north Pacific coast, where at several points in the States of Washington and Oregon it exceeds 100 inches annually, but diminishes southward so that at San Diego, Cal., the rainfall is very light and desert conditions prevail. Inland, back of the Coast Ranges, the northern part of the great depression separating these mountains from the Cascades and the Sierra Nevada is well watered. The amount of rainfall diminishes southward, so that in the southern part of the depression, which is occupied by the San Joaquin Valley, precipitation is scanty and arid conditions exist. The high mountains of the Cascade Range and of the Sierra Nevada are copiously watered, but east of them, in the valleys and low plateaus and on the great plains as far east as the one hundredth meridian, the rainfall is very light. The mountains of this (the Rocky Mountain) region, however, enjoy a more copious rainfall than the valleys, the amount differing with the altitude and latitude, the more northerly and higher ranges receiving the greater amount.

Continuing eastward, the small supply of moisture still remaining from that brought from the Pacific Ocean is augmented by a generous contribution from the Gulf of Mexico, and the rainfall increases. Upon much of the Gulf coast it exceeds 60 inches annually, but it diminishes northward, until in the neighborhood of the Great Lakes the precipitation does not exceed 30 inches yearly. The Appalachian Mountains are abundantly watered, and the Atlantic plain receives everywhere a sufficiency for agricultural purposes, derived largely from the Atlantic Ocean.

The causes of these great differences in amounts of precipitation in the various parts of the country are simply explained. All air holds a certain amount of moisture, ranging from the amount sufficient to saturate it to a very small proportion of that quantity. The point of saturation is much higher in warm air than in cold air; i. e., warm air can hold a much larger quantity of moisture than can cold air. Whenever air is cooled below the point of saturation, rain falls, and it can only fall when thus chilled. There are several ways in which air currents may be cooled; the current may be forced upward, as when it climbs the slope of a mountain range; it may be cooled by intermingling with colder air currents; and again, by coming in contact with a cold land.

The sea receives heat slowly and parts with it slowly; the land, on the contrary, is rapidly heated and parts with its heat as quickly. It results from these conditions that the ocean has a fairly uniform temperature the year around, while the land is much colder in winter than in summer.

Now, let us apply these principles to the United States. The prevailing winds in the Temperate Zone are from the west. These winds come off the Pacific laden with moisture and having the temperature of the ocean. If they encounter land having a lower temperature they are chilled below the point of saturation and some of the moisture is deposited in the form of rain or snow. If, on the other hand, the land is warmer than the air, the currents pass over it without any reduction in temperature and with little or no loss of moisture.

During the winter the north Pacific coast is colder than the sea, and hence the copious precipitation which it enjoys at that season of the year. In the summer the conditions are reversed, and the air currents, although containing at least as much moisture as in cold weather, pass over the land with comparatively little loss from precipitation. Southward, down the coast, the land is progressively warmer in winter, and consequently receives less rain, while in southern California there is little rain even in winter, except upon the mountains. Although the atmosphere at Los Angeles contains more moisture than does that at Washington, D. C., rain seldom falls in the former locality, as there is nothing to cool the air currents.

Thus it is that the Pacific coast has well-defined wet and dry seasons corresponding to winter and summer in other parts of the country. In winter the country drains the air currents of their moisture and they pass eastward as dry winds, while in summer these currents carry most of their moisture over the mountains and precipitate it upon the Rocky Mountains farther to the east and upon the great plains. Hence, it is that in these two regions the greater part of the year's rainfall occurs in the warmer half of the year.

Going eastward into the Mississippi Valley the moist air currents, drawn northward from the Gulf of Mexico by southerly winds, are carried progressively into more northerly and colder climates, and part of their moisture is deposited in a similar manner.

The Weather Bureau has furnished the Commission with data upon precipitation from about 4,000 stations within the limits of the United States proper. These data consist of records of the normal yearly and monthly rainfall, and the study which has been made of them is very illuminating.

For the preparation of a rainfall map, the data from all these stations were platted upon a large-scale map of the United States, and in the plains and level country generally isohyetal lines were sketched at intervals of 10 inches of rainfall in accordance with these data. In the mountain regions, however, but little weight was given to the rainfall data, inasmuch as the stations are generally situated in the canyons rather than on the ridges, and hence do not represent well the rainfall of the region, but in such country consideration was given to the relief of the land, its mountains, etc., and to the character of its vegetation; it is known, for instance, that the lower limit of yellow pine timber is not far from the isohyetal line of 20 inches. The areas between these isohyetal lines were measured by planimeter, and the average rainfall of each such area was assumed to be the mean of the two isohyetal lines limiting it. The areas were then multiplied by their average rainfall, the products summed up, and the total divided by the total area of the country. In this way the figure, 29.4 inches, was obtained as the mean average rainfall of the United States.

Another use has been made of these data. The percentage of the annual rainfall which was received during the six warmer months was computed for each station, and the results platted upon a map, which thus shows the preponderance of summer or winter rainfall throughout the country. Over most of the area the greater part of the rain occurs in the warmer season, but upon the Pacific coast and in the Rocky Mountains as far east as western Montana, eastern Idaho, eastern Utah, and Arizona the bulk of the precipitation comes in the colder season. The highest proportion, three-fourths to four-fifths of that of the year, is on or near the Pacific coast, and the proportion diminishes eastward. Again, in an area adjacent to the Gulf of Mexico, winter rainfall preponderates slightly. The highest proportional summer rainfall is on the plains east of the Rocky Mountains, where it ranges from three-fourths to four-fifths of that of the year. In the Mississippi Valley and on the Atlantic plain the proportion which falls in the warmer season is but little more than half of the annual precipitation.

TRANSPORTATION BY WATER.

By Herbert Knox Smith,
Commissioner of Corporations.

Part I.—GENERAL CONDITIONS OF TRANSPORTATION BY WATER.

The first part of this discussion on Transportation by Water in the United States deals with the general conditions of such transportation, involving the following topics:

(1) The natural and artificial coastwise and inland waterways, and the character and results of the more important improvements thereof.

(2) Vessel equipment, types, and number and tonnage.

(3) Vessel ownership, business organization, and finances of navigation lines and companies, in regular lines, bulk carriers, and towing concerns.

(4) Contracts for the carriage of goods, shipping documents, the liability of carriers, and statutes relating thereto.

(5) Marine insurance and its general influence on water transportation.

(6) Taxation of vessels and of navigation companies.

The present Part I is of a somewhat preliminary nature. It sets forth mainly conditions familiar to those in the business, though not hitherto presented to the public in complete form. Such a survey of conditions is necessary as a preparation for the discussion of the specific branches of the subject in subsequent parts of this report.

This report deals only with domestic traffic, except so far as foreign traffic is incidentally involved in such discussion. The domestic water-borne traffic carried by vessels of the United States is far larger than the foreign trade so carried, and of much greater importance. Coastwise traffic is by law restricted to American vessels. Most of the foreign trade is carried in foreign vessels. Domestic coastwise commerce, however, uses the same ports as does the foreign commerce, and the early policy of the Government in improving these ports, with especial view to foreign trade, gave also especial advantage to coastwise trade. In physical characteristics also the coastwise business is of the same class as foreign business, while the two differ largely from inland water traffic.

WATERWAYS AND THEIR IMPROVEMENT.

Interstate commerce moves on natural and artificial waterways. The former embrace the Atlantic and Pacific coasts and the Gulf of Mexico, the Great Lakes, and numerous navigable streams. These natural waterways have been greatly improved. Artificial waterways are government, state, and private canals.

COAST LINE.

The Atlantic coast line of the United States is more than 2,000 miles in length, and it is extended for another 1,900 miles by the Gulf of Mexico. The Pacific coast line is more than 1,800 miles long. The total coast line of the United States aggregates 5,700 miles. This is increased to a meandered length of 64,604 miles by including the numerous indentations, many of which provide important bay, sound, and inlet routes. Chief of these are the Gulf of Maine (so-called), Long Island Sound, Delaware Bay, and Chesapeake Bay, on the Atlantic coast, and Puget Sound, on the Pacific coast.

GREAT LAKES.

Next in significance are the Great Lakes, the most important group of inland waterways in the world. Their shore line in the United States territory is 2,760 geographical miles. The meandered length is 4,329 miles. They are connected by a series of natural and artificial channels. Canals also connect the Lakes with the Atlantic Ocean and the Mississippi and Ohio rivers, but these are not of dimensions to permit of through navigation by large vessels. Another series of canals, constructed by the Canadian government along the St. Lawrence River, give 14 feet draft to Montreal, and are used to some extent by American vessels.

On the coasts the Government has deepened harbors and connecting channels. Similar works on the Great Lakes give a depth of 20 feet on the main channels.

COAST AND LAKE ROUTES.

The coastwise trade routes radiate mainly from a few central ports, such as Boston, New York, Philadelphia, and Baltimore, on the Atlantic coast, and San Francisco, Portland, and Seattle, on the Pacific. On the Lakes, notwithstanding the large number of routes, the great movement of traffic follows a few well-defined main lines. Most important is the route from Lake Superior ports through Lake Huron to Lake Erie ports. Another main route, formerly the most important, is that from Lake Michigan ports to ports on Lake Erie.

RIVERS.

The number of navigable streams used to a considerable extent for commercial purposes in the United States is about 295, with an approximate mileage of 26,400.

Number and mileage of navigable streams in the United States, by districts.[a]

	Streams.	Navigable length.		Streams.	Navigable length.
		Miles.			*Miles.*
Tributary to the Atlantic	148	5,365	Flowing into Canada	2	315
Tributary to the Gulf, exclusive of the Mississippi and tributaries	53	5,212	Tributary to the Pacific	38	1,606
Mississippi River and tributaries	54	13,912	Total	287	26,410

[a] No classification of this sort can, of course, be absolutely accurate. Sections of a river that might be rendered navigable are not included, nor streams practically abandoned for navigation purposes. There are also many small streams navigable for very light vessels in local commerce which have not been included.

The chief of these are:

Navigable lengths and depths of principal rivers of the United States.

Rivers.	Navigable length.	Depth.	Rivers.	Navigable length.	Depth.
Atlantic coast:	*Miles.*	*Feet.*	Gulf of Mexico—Continued.	*Miles.*	*Feet.*
Penobscot	27.0	11.0	Atchafalaya	156.0	....
Kennebec	44.0	10.0	Calcasieu	58.0	3.5-12.0
Connecticut	50.0	10.0	Sabine	64.0	5.0
Hudson	150.0	[a]9.0	Neches	135.0	3.0
Delaware	82.0	[b]6.0	Brazos	200.0	– 4.0
Potomac	113.0	18.0	San Jacinto (Buffalo Bayou)	27.0	7.5-18.5
Rappahannock	106.0	7.5	Mississippi system:		
York	41.0	20.0	Mississippi	2,429.0	2.0-32.0
James	103.8	16.0	Below New Orleans	....	32.0
Pamlico and Tar	108.0	2.5- 8.5	New Orleans to St. Louis	....	9.0
Cape Fear	145.0	(c)	St. Louis to St. Paul	....	4.5
Waccamaw	147.0	2.0-12.0	Above Minneapolis	....	3.0
Pedee	172.0	2.0- 8.0	Ohio	967.0	4.2-21.0
Santee	143.0	4.0	Monongahela	131.0	7.0
Savannah	250.0	[d]3.0-21.0	Kanawha	90.0	6.0
St. Johns	276.0	[e]2.0-20.0	Green and Barren	227.0	5.0
Gulf of Mexico:			Cumberland	518.0	....
Withlacoochee	77.0	2.0- 5.8	Tennessee	652.0	1.5- 3.0
Suwanee	135.0	4.0- 5.0	Missouri	2,414.0	....
Apalachicola, Flint, and Chattahoochee	465.0	3.0- 6.0	Yazoo	173.0	3.5
Alabama	312.0	3.5	Ouachita and Black	436.0	....
Coosa	198.0	2.0	Red	500.0	2.0
Mobile	45.0	14.0	Pacific coast:		
Tombigbee	341.0	3.0- 6.0	San Joaquin	200.0	3.0-8.0
Warrior and Black Warrior	154.5	6.0	Sacramento	282.0	2.5- 7.0
Pascagoula	55.0	5.0-15.0	Columbia	336.0	[f]3.5-20.0
Bayou Plaquemine, etc.	11.0	....	Willamette	164.0	[f]3.0-22.0
Bayou Teche	75.0	4.0	Snake	146.0	3.5
Bayou Lafourche	105.0	3.0			

[a] 25 feet to Hudson.
[b] 23 feet to Philadelphia.
[c] 20 feet to Wilmington, 8 feet to Kings Bluff, and 2 feet to Fayetteville.
[d] 21 feet to Savannah.
[e] 20 feet to Jacksonville, 5 feet to Sanford.
[f] 20 feet to Vancouver, Wash., and Portland, Oreg., 8 feet to The Dalles.

LACK OF UNITY IN WATER SYSTEM.

The streams tributary to the Atlantic do not form connected systems, but often form extensions of coastwise routes into the interior. Streams tributary to the Gulf are more often connected with each other, foremost being those of the Mississippi Valley system, which aggregate about 14,000 miles. On the Pacific coast there are also several connected systems, such as the rivers leading into Puget Sound, the Columbia River and its tributaries, and the rivers of central California.

Most streams included in the foregoing table are navigable only for light-draft boats. Forty streams have a total of about 2,600 miles of 10-foot navigation, and 70 streams give about 3,200 additional miles of navigation of from 6 to 10 feet during the greater part of the year, a total of about 5,800 miles of river navigation of 6 feet and over. These totals, however, do not of course mean that there are any such continuous stretches of inland waterways of these respective depths. The greater number of these streams flow into the Atlantic, but few of the Atlantic rivers have more than 100 miles of navigation over 6 feet in depth. The longest connected river system is the Mississippi and its principal tributaries, with about 2,500 miles of a depth of 6 feet or more.

It is evident that rivers having a navigable depth of only 6 feet can not be used by vessels suited to ocean or Great Lake navigation, and furthermore, that vessels which give the most economical service on rivers having that depth can not be used on still shallower rivers. These facts, together with the shortness of the navigable length of most rivers having a 6-foot depth and their unconnected character, are of great importance in estimating the present value of our inland waterways. It is evident that these waterways constitute by no means a unified system. The predominating importance of through traffic in modern transportation makes this lack of unity a serious defect, and accounts to a considerable degree for the failure of our waterways to hold their own in competition with the rail system.

CANALS.

About 4,500 miles of canals have been constructed in the United States. Of these, 2,444 miles, costing in all about $80,000,000, have been abandoned.

The height of interest in canal building came about 1827 to 1837, after the success of the Erie Canal. The crisis of 1837 stopped canal building for the time. The introduction of the railroad about this time was also an important factor in this decline. Since then the use of canals has been as a whole steadily decreasing, both in absolute amount and still more markedly in proportion to the total traffic of the country.

This is due in part to improvident original location of the canals, in part to mismanagement and to adverse control of strategic connections and terminals, but above all else to the fundamental inability of the ordinary type of towpath canal to meet modern conditions of transportation. They are thus unable to compete with railroads to any considerable extent.

Notwithstanding these facts, private and State canals still exist. State canals are maintained in New York, Ohio, Illinois, and Louisiana, with a total mileage of nearly 1,360, constructed at a cost estimated at $156,983,538, as follows:

State canals in operation in the United States.

Name and location.	Termini.	Length.	Depth.
		Miles.	*Feet.*
New York:			
Erie	Buffalo and Albany	355.1	7
Champlain	Troy and Whitehall	81.0	5
Oswego	Oswego and Syracuse	38.0	7
Cayuga and Seneca		25.0	7
Ohio:			
Ohio and Erie	Cleveland and Portsmouth	326.0	4
Miami and Erie	Toledo and Cincinnati	269.0	4-6
Illinois and Michigan	Chicago and La Salle	101.9	6
Chicago Sanitary and Ship Canal	Chicago and Lockport	33.0	22
New Basin Canal (Louisiana)	New Orleans	6.7	8

The Ohio and Illinois canals are antiquated waterways, with little traffic; and the Erie Canal, in spite of its important past, is inadequate in its present condition to meet modern traffic demands, although the new barge canal in course of construction by the State of New York is intended to give a revival of this route.

There are 16 private canals in operation in the United States of more than local importance, with an aggregate mileage of 632, as follows:

Private canals in operation in the United States.

Name of canal.	Termini.	Length.	Depth.
		Miles.	*Feet.*
Delaware and Raritan	New Brunswick and Bordentown	66.0	8-9
Morris	Philipsburg and Jersey City	106.7	5
Lehigh	Coalport and Easton	48.0	6
Delaware Division	Easton and Bristol	60.0	6
Schuylkill Navigation		90.0	6½
Chesapeake and Delaware		13.6	10
Chesapeake and Ohio	Cumberland and Georgetown	185.0	6-7
Dismal Swamp		22.1	9
Albemarle and Chesapeake		11.0	9
Fairfield (North Carolina)		4.0	6
Newbern and Beaufort (North Carolina)		3.2	5
Old Basin (Louisiana)		2.5	7
Barataria and Lafourche (Louisiana)		7.0	6
Harvey's (Louisiana)		5.35	6
Lake Borgne (Louisiana)		7.0	7
Willamette Falls (Oregon)		.6	6

The capital stock reported by 8 companies owning these canals is $43,326,539. Their total indebtedness as reported to the Bureau is $38,307,740. The more important private canals are those comprising the Atlantic coast system, which connect natural waterways so as to furnish continuous inland communication for light-draft vessels from the sounds of North Carolina to Long Island Sound, though their use for such long-distance traffic is wholly insignificant. Most of these canals have a declining traffic. Little has been done in the way of improving them since the civil war; and several have come into the possession or control of railroads, which appear to discourage their use. The control of canals by private interests does not appear to be successful. Such private control also to some extent impedes free use of the natural waterways with which they are connected.

The "towpath canal," forming a route in itself, and not a mere short connecting link or extension of deep open routes, is wholly outclassed in attempting to meet the demands of modern transportation. Using animal power, they are too slow for most high-grade traffic. The depth of water seldom exceeds 7 feet, so only small boats can be used. Moreover, it is unable to furnish feeder lines, factory sidings, etc., with the ease of the rail system. The bulk of our traffic is now so largely long-distance that even the longest canal can not depend on traffic wholly originating and terminating within its limits; and when it thus has also to seek long-distance traffic, for which it is merely one link in the chain, it meets heavy rail competition, difficulties of transshipment, and difficulties of connecting terminals. This struggle is so keen that the slightest original disadvantage may easily determine the issue.

The question as to the value of a canal for steam-towed barges of 1,000 to 1,500 tons is still to be determined by practical use.

WATERWAY POSSIBILITIES AND LIMITATIONS.

At first glance the possibilities of our present natural system, if properly developed, seem great; but any proper plan of development must first consider in detail a number of physical and economic restrictions, which place very decided limits on waterway traffic, especially inland river traffic. Differences in types of waterways are of great importance. The extreme physical differences between deep, open water routes, like the sea or the lakes, and the shallower, winding, and narrow channels of rivers and canals, make the use of the two not at all comparable. Arguments as to one can not be safely based on the facts of the other. A corresponding difference in types of vessels suitable thereto and now used thereon is a natural consequence. These two conditions impose great restrictions on the complete unification of the system, and what may be called the interchangeability of the floating equipment, and consequently on through shipments.

This lack of unity and of interchangeability is a factor of enormous importance in the use and development of waterways and their relations with the railroad system.

GOVERNMENT AND STATE IMPROVEMENTS.

Until about 1850 the improvement of navigable streams and the construction of artificial waterways in the United States were principally carried on by the several States and by private corporations. Both classes of enterprises, however, were sometimes encouraged by the United States Government, either by appropriations or, more frequently by land grants and subscriptions to stock.

Since about 1870, the date of the present form of the river and harbor bill, the policy of the United States Government has undergone a radical change. Many improvements formerly conducted by States and private corporations have been taken over by the Government, and the amounts appropriated for waterway improvements have been largely increased. The total federal appropriations for river improvements and canals (excluding harbor works) to 1907 have been about $250,000,000.

Canals owned by the Government form links in through-water routes, such as the St. Marys Falls Ship Canal, rather than distinct routes in themselves. The improvement of rivers by the Government has consisted in the removal of obstructions to navigation, the deepening of channels, the construction of revetments, and the development of slack-water navigation by the building of locks and dams for the purpose of maintaining a proper depth. Such improvements have been carried out to some extent on most of the navigable streams of the country, the most comprehensive and connected system of river improvement being that of the Mississippi and some of its important tributaries.

COOPERATION IN IMPROVEMENTS.

In the development of our waterway system, while undertaken in part by state and later and more extensively by federal power, there has been very little of that cooperation between central and local authority that appears in the best of the European systems. The United States, the States, the counties, levee districts, and municipalities have all spent large sums of money on waterway improvement, but for the most part separately. There has thus been waste, lack of uniformity, lack of comprehensive plan, and especially a lack of any proportionate contribution from localities peculiarly benefited.

While it is true that the entire country is to some extent interested in a good waterway system in each part thereof, nevertheless it must be remembered, as pointed out above, that any complete unification of that system is, for the present at least, physically impossible, and that therefore the traffic on such waterways will remain for a time confined to certain large sections of the country, and the benefits thereof will also to a considerable degree be local. European countries have in many cases met a similar condition by a distribution of costs of improvements apportioned upon localities in some ratio to special benefits received.

EQUIPMENT EMPLOYED IN TRANSPORTATION BY WATER.

TYPES OF VESSELS.

These include various classes of craft, such as sailing vessels, steam vessels, gasoline boats, barges, and canal boats. Steam vessels show a continuous and rapid increase both in number and tonnage. They have exceeded sailing vessels since 1895 and now have more than double the tonnage. Sailing vessels have declined in importance since 1860. There has also been a notable increase in the number of barges hauled by towboats, especially on the Mississippi and its tributaries and on the Atlantic and Gulf coasts, showing an important change in the form of traffic movement. The total number of unrigged craft in the United States in 1889 was 16,937, as compared with 20,263 in 1906.

Special recent developments in the types of vessels are particularly noticeable in regard to vessels for bulk cargoes. Thus there are the grain and ore bulk carriers on the Great Lakes; steam freighters and coal, fruit, and oil carriers on the Atlantic and Gulf coasts; and steam schooners on the Pacific coast. The competition of such vessels with sailing vessels has, in turn, led to the building of four, five, six, and seven masted schooners. Older sailing vessels are often converted into schooner barges, which are towed from port to port. Gasoline boats are coming into use for local traffic on the rivers of the Mississippi Valley and on the Pacific coast. A type sui generis is the log or lumber raft, notably the huge "cigar rafts" on the Pacific coast.

VESSEL TONNAGE.

The total gross tonnage of documented vessels engaged in the domestic trade in 1896 was 3,858,927 tons, and in 1906, 5,735,483 tons, a gain of 1,876,556 tons, or 48 per cent. The tonnage of American vessels engaged in the foreign trade, after reaching its maximum in 1860, has continued to decline except for a slight increase since 1900. In 1896 it was 884,954 tons, and in 1906, 939,486 tons, an increase of only 94,532 tons, or 11 per cent.

The distribution of domestic vessels by districts in 1907 shows that the Atlantic and Gulf coasts are the most important districts, including nearly half of the total documented tonnage and two-thirds of the sailing-vessel tonnage. The Great Lakes have more than one-third of the total documented tonnage and almost half the total documented steam tonnage of the United States.

There has been a notable increase in the size of vessels on the coasts and the Great Lakes, similar to the increase in the size of railroad rolling stock, and with similar results in the reduction of transportation costs. As a general rule, and with vessels of the same type, the larger the vessel the lower the cost of carriage.

The size of vessels is, however, limited in nearly all cases by the depth of channels and harbors and by the terminal accommodations. Though the limits vary widely on different classes of waters and at different ports and channels, it may be said in general that a great many vessels have already been built with as great draft as the waterways they use will permit, and that in the case of most of our rivers and canals the maximum draft of vessels is scarcely sufficient to permit very economical operation. This fact has an important bearing on the possibilities of successful water transportation.

DIVERSITY IN VESSELS.

Reference has already been made to differences in depth of different classes of waterways as requiring differences in the size of vessels. These necessitate transshipment in order to secure through transportation, even between points both of which are on connecting waterways. Other differences in physical conditions of different kinds of waterways also prevent the use of the same vessels for through shipments. Thus vessels used on quiet inland waterways, such as smaller inlets and lakes and on rivers and canals, are neither sufficiently strong nor have they sufficient freeboard to permit them to be used on the Great Lakes or the ocean. Naval architects even assert that were there enough channel depth to take vessels from the Great Lakes to tidewater, nevertheless it would be preferable, and almost necessary, to tranship at tidewater as now. Ore vessels on the Great Lakes, they state, are not in model or in structural strength adapted for ocean conditions.

Again, the narrowness and tortuousness of river channels almost entirely prevent the use of sailing vessels, and practically also prevent the use of large steam vessels such as are adapted to the Great Lakes or the ocean. Thus, even on a channel as deep as the Hudson practically no large ocean boats are seen at any considerable distance above New York, though there is 25 feet depth of water up to Hudson, 100 miles above New York. Owners do not care to risk the dangers of a restricted channel with large ocean-going craft. Again, in the present state of the art, even light-draft screw steamers can not be used to advantage, generally, on the Mississippi at any considerable distance above New Orleans. Aside from the shallow depth, the need for constant backing and turning at the innumerable bends makes the stern-wheel paddle the only generally successful method. The latter, of course, is useless on the open sea.

SPECIALIZATION OF BULK-CARGO VESSELS.

Specialization in vessels is not only with respect to the peculiar condition of the waterways, but it has gone further in adapting them to the peculiar conditions of the different kinds of traffic. This adaptation is especially conspicuous in what are known as bulk-cargo vessels; that is, vessels which do not carry package freight, or diversified freight, but which carry one or at most a few kinds of articles in bulk. Thus on the Great Lakes bulk steam vessels for ore or coal, and others for grain, are used to an enormous extent. On the Atlantic and Gulf coasts there are bulk vessels for coal, for oil, for fruit, etc. On the Pacific coast a type of steam schooner has been developed, especially intended for hauling lumber in bulk, and special lumber vessels are also used on the Great Lakes and the Atlantic Ocean. On the Ohio and Mississippi bulk coal barges are extensively used, and other bulk boats to some extent. The use of rafts of logs on the Great Lakes, on the rivers, and on the Pacific coast is a special development of bulk transportation.

The great predominance of bulk traffic emphasizes this specialization in vessels. On the Great Lakes steam bulk freighters carry about 80 per cent of the total business. The bulk coal traffic on the Atlantic and lumber traffic in steam schooners on the Pacific represent an important part of the total coastwise commerce. On the rivers of the Mississippi Valley the bulk carriers and rafts handle about three-fourths of the total traffic.

This development of the bulk water carrier is highly significant of the peculiar demands of modern transportation. It has been most successful in those cases where the products to be shipped are either on or very near the water, and where the destinations to be reached are likewise on or near the water. This is conspicuous, for example, in the case of the coal carried on the Monongahela, Ohio, and Mississippi rivers, most of which is produced at or very near the rivers. At the same time a large part of the traffic in bulk water carriers reaches those carriers only by rail haul, and a considerable part is delivered by rail to the final destination. This occurs, as on the Lakes, where there is a large uniform supply, a corresponding demand, and a proportionately long water haul connecting the two.

This specialization of types of vessels, as in the various classes of bulk freighters, in the use of gasoline launches on the Mississippi River, etc., indicates the struggle of a system to adapt itself to its conditions. Probably had there been no rail competition, that adaptation would have gone much farther and would have approached something like a good operating system, even on the inferior waterways, such as rivers and canals. But in the keen struggle with the railroad for existence, hand-to-mouth methods have been necessary, except on the Great Lakes and the coast, and even there it is to some extent hampered by rail competition. Could the rail and water systems have cooperated instead of competing, it seems probable that a reasonable share of traffic would have produced a modern system of waterways transportation even on our smaller rivers.

From these considerations as to the character of our waterways, and of the vessels used upon them, it is obvious, as already stated, that our inland waterways are far from constituting a unified system, and that, save on the Great Lakes and in the coal traffic on the Ohio, they are very inferior in efficiency to railroads. In a later part it will be shown that the traffic on rivers and canals of the United States is insignificant in comparison with the rail traffic, or with traffic on the Great Lakes and the coasts. Diversity in water-route and channel conditions, diversity in vessel types, in motive power, and in terminals, as well as in carriers' liability, insurance, freight classification, and traffic contracts generally, have resulted in extreme absence of organization of our water system as a whole. It is thus helpless in competing for long-distance traffic with a modern, unified, standardized system like that of the railroads.

LIMITATIONS OF TRANSSHIPMENT.

It can not be expected that any reasonable expenditure on our inland waterways will wholly remove these difficulties. It would never pay, except in a few cases, to try so to deepen and improve the rivers and canals as to permit vessels suited to the ocean to use them to any appreciable extent. Transshipment from one water carrier to another will continue to be necessary on most long inland, or partly inland, hauls, even from and to points actually on waterways. Moreover, the greater part of our traffic originates in, or is destined to, points not on waterways, so that transshipment from rail to water will always be necessary on most longer hauls which seek to use the waterways at all.

Since such a large portion of our traffic is long-distance traffic which will thus involve transshipment, the question of the future development of our inland waterways resolves itself into one of relative operating expenses and of investments of capital. There is little doubt that for a given distance a continuous water haul in a boat of even moderate size is, and will continue to be, cheaper in operating costs alone than a similar continuous rail haul. If the channels are made deep enough to permit the use of relatively large boats, this greater cheapness will, in some cases, probably be sufficient to cover also the additional cost of transshipment. The question is, however, whether besides doing so it will afford enough saving to cover reasonable interest on the investment in waterways and water terminals necessary to secure such measure of efficiency. This is a question which can only be answered after most exhaustive engineering estimates of the cost of constructing waterways of different depths and most thorough investigations of operating expenses of different kinds and sizes of vessels, in comparison with expenses of rail transportation.

It should be noted, however, in considering how far expenditures of capital for improved water routes are advisable, that in some cases the railroads have already reached the limit of their carrying capacity and that they will have to make additional investments of capital if they are to meet the demands of transportation. The relative amount of investment necessary thus to increase the facilities of the railroads, as compared with the investment necessary to afford adequate water routes and terminals, must therefore likewise be taken into account.

BUSINESS ORGANIZATION AND FINANCES.

OWNERSHIP.

Prior to the development of steam navigation vessels were usually owned and operated by individuals or small groups of individuals. Sailing vessels are even now more commonly thus owned than by corporations. The corporate form, however, has gained steadily, at first with steam vessels and later with sailing vessels and barge lines. There was a total of 37,321 vessels, with a total gross tonnage of 12,893,429 tons, and valued at more than $507,000,000, included in the census of 1906. Of these, corporations owned more than one-half of the number, and more than three-fourths of the total tonnage and value. Of steam vessels corporations controlled 42.6 per cent, representing 87.6 per cent of the gross steam tonnage; and of freight and passenger vessels running on regular lines they controlled 56.8 per cent, with 91 per cent of that tonnage. The proportion of vessel tonnage owned by corporations is everywhere larger than the proportion of the number of vessels so owned, indicating that the vessels owned by corporations are usually the larger ones. In 1906 the average size of vessels owned by individuals was 113 tons, of vessels owned by firms 223 tons, and of vessels owned by corporations 526 tons.

Many steamship corporations, however, are essentially private affairs, with few stockholders. They often are controlled by a few individuals, often of the same family. Navigation companies have been in most cases conservatively capitalized and their stock not offered in the open market. But in recent years there have been some notable changes in these respects. By expansion or consolidation there have been developed quite a number of great corporations with large fleets and operating many lines over a wide territory. The most striking instance of consolidation is that of the Consolidated Steamship Lines, commonly known as the Morse combination, including half a dozen important Atlantic coast lines, covering a large share of the regular packet-line business in this important district.

An especial feature has been the recent acquisition and operation of steamer and barge lines by railroad companies and by industrial and trading concerns, including several of the great combinations, such as the United States Steel Corporation, the Standard Oil Company, the Southern Pacific Railroad Company, the New York, New Haven and Hartford Railroad Company, the New York Central Railroad, the Pennsylvania Railroad, and others.

FINANCIAL.

The information available is inadequate for a satisfactory discussion of financial operations. The scope of the data is limited to a few of the most important facts relating to the capital stock (in case of corporations), indebtedness, gross earnings, and operating expenses. But even on these points the failure of many concerns to make any report renders the details incomplete, and only a few general and tentative conclusions can be drawn therefrom.

The information in regard to capital stock and indebtedness is more complete than in regard to earnings and expenses, but even there special difficulties are encountered. Where navigation lines are owned by railroads or industrial corporations there is usually no specific record of the capital invested in the navigation lines as distinguished from the remaining property of the corporation.

The aggregate capital stock of navigation companies reported to the bureau is $248,720,178; the aggregate bonds and other indebtedness is $170,387,005, making a total capitalization of $419,107,183. This is for 366 companies, operating less than half the total vessel tonnage in the United States.

In the information as to earnings and expenses, the utter absence of anything approaching uniformity in the method of accounting makes the returns of limited value. The aggregate gross earnings of concerns reporting earnings and expenses amounted to $81,708,289, and their aggregate operating expenses amounted to $65,816,251, leaving net earnings of $15,892,038. Operating expenses thus averaged 80.6 per cent of the gross earnings, a ratio of operating expenses to gross earnings much higher for navigation lines than for railroads, which in 1906 showed a ratio, for the United States as a whole, of 66¼ per cent. This is not surprising, as out of their own earnings railroads must pay large sums on account of the fixed charges for their roadbed, for which there are no corresponding charges in the case of most navigation companies.

An analysis of the ratio of operating expenses to gross earnings, by districts, is of interest.

	Lumber carriers.	Coal carriers.	Bulk carriers.	Packet lines.	River lines.	All lines.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Great Lakes			69.7	85.7		77.2
Atlantic and Gulf coasts			83.3	79.2		79.8
Mississippi and tributaries		79.3			86.8	83.7
Pacific coast	75.8			*85.7	84.7	85.4

* Ocean packet lines.

The bulk carriers on the Lakes show the smallest ratio of expense. This is natural, as a result of the great predominance of bulk-cargo traffic there and the high degree of specialization thus made possible in carrying and terminal methods. The highest ratio of expenses is for the packet lines on the Mississippi and southern rivers.

The high operating cost of the Pacific coastwise packet lines is somewhat misleading, due partly to the heavy loss of one company in a special branch of business since abandoned. The normal ratio there would be about 81 per cent.

The incomplete nature of the statistics and the absence of information as to the relation between the capitalization of navigation lines and the cost and value of their equipment and property makes impossible a comparison of the net earnings with the actual investment, to show correctly the profitableness of the business. It may be said, however, that in the case of the companies reporting, the average net earnings are a fair rate on the capitalization; but there are wide variations between different companies, some showing a very high rate of return on the capital, others reporting operating expenses in excess of gross earnings.

SHIPPING CONTRACTS AND DOCUMENTS.

Transportation by water is the oldest method of long-distance traffic. It is in large measure governed by a body of world-wide maritime usages of remote origin. These customs have, however, been modified by statute, especially since the development of inland navigation and its closer connection with railroads. Various ports also have local rules.

In securing cargoes, regular steamship lines, like railroads, make use of traffic agents of their own, but in the case of bulk cargoes and "tramp" vessels ship brokers, acting for both parties, are often employed.

CHARTERS AND BILLS OF LADING.

The vessel may be let or hired by a charter, or the vessel may have a regular route, its owner or operator accepting shipments as a common carrier, in which case it is technically known as a "general ship." The two instruments most commonly employed in contracts of carriage are the charter party and the bill of lading. The former is a contract for the whole or a large part of the vessel; the latter for a smaller and varying portion of the vessel's capacity. There are numerous forms of both classes of documents employed, although efforts have been made to secure the use of uniform contracts.

The practice of leasing vessels is quite common throughout the United States. In some instances all the vessels of an operating company are chartered by it from the owners. Some vessels operated in the foreign trade are chartered by the year from foreign owners.

Bills of lading issued by vessels correspond in a general way to those issued by railroads. There is considerable diversity, especially in clauses limiting the liability of the carrier. The New York Produce Exchange steamship bill of lading is one often employed. Some clauses in many bills of lading appear to conflict with the provision in the Harter Act prohibiting a vessel owner from inserting stipulations to relieve himself from the results of negligence.

MANIFESTS.

These correspond to railroad waybills, showing the cargo of vessels on each voyage. In the case of foreign voyages, and on the Great Lakes, manifests must be filed with the customs officers; but they are not ordinarily required to be filed for other coastwise or river routes. This is a serious obstacle to the collection of complete statistics of water-borne traffic in the United States.

GOVERNMENT REGULATION.

The interstate-commerce acts have been applied only in a limited degree to carriers by water; and it is uncertain how far the provisions of these acts as to rates and carriers' liability are intended to apply to water lines. This is in marked contrast with the close supervision over vessels and their officers for the protection of life. In this latter respect water traffic has long been far more closely regulated by government control than railroad traffic. The detailed strictness with which the construction, operation, and maintenance of vessels is watched by the Government, and its complete system of inspection thereof, is in very marked contrast to the almost complete absence of such control over railroads. This difference, also, has borne with some disproportionate weight on the water traffic.

On the other hand, governmental control of rates has been much more complete over railways than over waterways.

MARINE INSURANCE.

Marine insurance charges are an important factor as an addition to the cost of transportation by water, and they must be taken into consideration in comparing the relative economy of rail and water routes.

VARIATIONS IN POLICIES AND RATES.

Since the floating equipment and cargoes protected by insurance are of various kinds, there is a similar diversity in the types and stipulations of insurance policies. As regards vessels, there are river hull policies, ferryboat hull policies, inland hull, tug, yacht, schooner, and steamboat policies. As regards cargoes, there are cotton policies, coal, lake-cargo, and river-cargo policies. There are also blanket policies on hull and cargo and on all the vessels and cargo of particular lines.

There is considerable variety both in the manner of effecting insurance on vessels and cargoes and in rates of premium, not only on the different waterways of the country, but also in respect to the several types of vessels and the freight transported. Inland policies are peculiar in the restrictions upon the routes on which the craft may operate, and in the varying rates of premium on different streams. Some vessels carry only fire insurance, others both fire and marine insurance, and others fire, marine, and port insurance. Often no vessel insurance or insurance of any kind is carried. Some vessel owners are their own insurers, providing special reserve funds for that purpose. Insurance on vessels is usually by the year, often with lay-up clauses applicable to the period during which navigation is suspended.

Cargo insurance in some cases is entirely attended to by the vessel owner on behalf of the shipper or consignee. Generally, however, it is effected on each shipment by the shipper and continues until the vessel reaches the port of destination or for a certain time thereafter. In other cases, however, especially with reference to bulk freight, the vessel owner or owner of cargo lots takes out a blanket policy covering all shipments for a given period.

The great portion of river hulls and shipments seems to be protected by insurance. Differences in the conditions of river improvement, navigability, and river dangers are reflected in the insurance rates. In fact, the cost of insurance is often a determining factor as between rail and river shipments. The rail carrier being practically, by law, the insurer of the freight, insurance on rail freight is a negligible consideration for the shipper. But on water, and especially river traffic, this is by no means so. Instances of river insurance rates are as follows:

A company operating on Virginia and Maryland waterways reports that the insurance premium for a recent fiscal year amounted to 3.1 per cent of the gross receipts. Cargo insurance on the Red River is 0.9 per cent of the value of the goods. On the Mississippi River from Vicksburg to New Orleans cargo insurance is 45 cents per $100, or about 20 cents per bale of cotton, which must be added to the freight rate of 75 cents per bale, thus making the insurance nearly one-third of the freight.

These high and varying rates of insurance not only increase the cost of transportation, but they also indicate the dangers of such traffic and add to the uncertainty and lack of uniformity so detrimental to shippers' interests.

There seems to be a general tendency for marine insurers to work in groups or combinations. A large proportion of the total risks assumed in the United States are taken by foreign companies. In the United States, marine insurance is largely written by corporations instead of by such associations as Lloyds, in England. There are nine important domestic companies, of which only one devotes itself exclusively to marine indemnity, the others combining fire and marine business, their fire-insurance business being larger than the marine.

TAXATION OF VESSELS AND OF NAVIGATION COMPANIES.

CONSTITUTIONAL RESTRICTIONS.

The power over interstate and foreign commerce vested in Congress, together with the specific prohibitions of the Constitution against state tonnage and customs duties without the consent of Congress, restricts the taxing power of the States over navigation as such, while leaving the States free to tax vessels like other property within their respective jurisdictions. Thus a tax on interstate traffic as such is unconstitutional, and the privilege of navigating public waters is not subject to state license tax; but States may under some conditions impose franchise taxes based in substance upon the gross receipts of transportation companies, even though part of them be derived from interstate traffic, or upon the capital stock of companies engaged in interstate commerce.

Tonnage taxes, no matter in what form, may not be imposed by a State on vessels simply because of their use of or presence in a public waterway, although where a State has made improvements in a waterway it may charge a toll for the use of those improvements, in reasonable proportion to the cost and maintenance of such improvements, even if such toll be calculated on tonnage.

Furthermore, a State or municipality may charge wharfage fees for the use of landing places provided by it, even if such fees be fixed on the basis of tonnage.

METHODS OF STATE TAXATION.

One of the common methods employed in the taxation of navigation companies appears to be an assessment of the capital stock at its market value, after deducting therefrom the assessed valuation of the corporation's vessels and other tangible property which are taxed like similar property belonging to individuals. The States using this method are Massachusetts, North Carolina, Alabama, Kentucky, Illinois, Kansas, Minnesota, and North and South Dakota. Several States, however, impose relatively light franchise or license taxes measured by the par value of the stock, and without regard to any taxes assessed upon the tangible property. These States are New Jersey, New York, Delaware, Ohio, West Virginia, Georgia, Texas, Colorado, and California. A number of others tax gross or net receipts as well as the capital stock and tangible property. These States are New York, Pennsylvania, Maryland, Virginia, and South Carolina.

In most of the States water craft of all kinds are assessed and taxed like other personal property, either at the residence of the owners or, what is often the same thing, at the port of enrollment, registry, or license. A few States provide for taxes measured by the gross or net tonnage in lieu of other taxes on such property, on the assumption that the value of vessels is roughly in proportion to size. Vessels engaged in the foreign trade are in several States favored either with exemption from taxation or with very light taxes based upon their net earnings. Massachusetts, which formerly taxed the net earnings or dividends in such cases, now assesses the property, whether belonging to individuals or corporations, at the low rate of one-third of 1 per cent—about one-fifth of the rate of taxation on other property. A low rate of taxation on vessel property is probably of advantage to the State imposing it, because of the ease with which taxation can be evaded in respect of property so easily movable.

FEDERAL TAX.

There is no federal tax on American vessels in domestic trade. The National Government imposes a tonnage tax on vessels entered at ports of the United States from foreign ports, at the rate of 3 cents per ton in the case of vessels from near-by foreign ports and 6 cents per ton when from more distant places, but not to exceed 15 cents per ton per annum in the former case or 30 cents per ton per annum in the latter case.

Part II.—WATER-BORNE TRAFFIC.

Part II deals with the following topics:

(1) The general nature of water-borne traffic, its development, and its present importance.

(2) Through traffic of the Atlantic and Gulf coasts.

(3) Traffic at various North Atlantic ports and on tributary inland waterways.

(4) Traffic at South Atlantic ports and on neighboring rivers.

(5) Traffic on Gulf of Mexico and its tributaries, exclusive of the Mississippi system.

(6) Traffic on the Great Lakes and connecting waterways.

(7) Traffic on the Mississippi River and its tributaries and connecting canals, and the Red River of the North.

(8) Traffic on the Pacific coast and streams tributary to the Pacific.

There are very important differences between coastwise, Great Lakes, river and canal, and harbor traffic, although, owing to the incomplete nature of available statistics, these classes can not always be accurately separated.

Following is a brief statement of the results of this part of the investigation:

Domestic water-borne traffic is mainly in passengers and freight. Both the domestic express and mail movements are unimportant, and except in the coastwise trade and on the Great Lakes the same is true also of the movement of passengers. Of the total of more than 366,000,000 passengers by water reported to the census in 1906, nine-tenths were carried by ferryboats. Those carried by other than ferryboats were less than one-twentieth of the number of passengers carried by rail.

IMPORTANT CLASSES OF FREIGHT.

Freight moved by water includes two general classes—first, so-called package freight, usually, but not always, in bags, boxes, barrels, or other packages, and also referred to as "general merchandise," "miscellaneous merchandise," or "steamboat freight;" and, second, bulk or coarse freight, usually shipped in cargo lots, and embracing the products of mines, fields, and forests. Freight moved by water in American vessels in 1906, including harbor traffic but excluding logs and lumber rafted and floated, aggregated more than 265,000,000 tons, as contrasted with 130,000,000 reported by the census in 1889. Much the larger part of this is domestic traffic, foreign traffic being mainly carried in foreign vessels.

On the coasts and the Great Lakes there was a very marked increase in the traffic from 1889 to 1906, that of the Great Lakes having trebled and that on the Atlantic and Gulf coasts having nearly trebled. On the other hand, on the Mississippi River and tributaries there was an actual decline, and on other inland waters reported separately by the census (mostly canal traffic) there was a very marked decline during this period.

Excluding harbor and raft traffic, the water-borne traffic in American vessels for 1906 amounted to 177,519,758 tons, of which 42.6 per cent moved on the Great Lakes and 36.8 per cent on the Atlantic and Gulf coasts and rivers. Of this traffic, more than one-half the tonnage consists of certain crude minerals (coal, iron ore, stone, and sand). Other bulky mineral products, such as petroleum and other oils, cement, brick, lime, ice, phosphate rock and fertilizer, and pig iron and steel rails constitute the third largest group. Lumber and naval stores form the second largest group, and the movement of logs and timber in rafts, which is not reported, would increase the total for forest products by a large amount. Agricultural products, including grain, flour, fruits and vegetables, cotton, and tobacco, also form an important group in volume and more important if the value of the commodities is considered. The above commodities, most of which are shipped as bulk freight, together form over 80 per cent of the traffic in American vessels.

Package and miscellaneous freight comprises about one-fifth of the movement reported for 1906, and is of the greatest importance on the Atlantic and Gulf coasts, where it represents nearly 30 per cent of the volume of freight handled. The movement of this class of traffic is, however, of varying degrees of importance on all of the water routes of the country.

SPECIALIZATION OF TRAFFIC BY DISTRICTS.

Traffic is considerably specialized by districts. Coal forms the largest tonnage of any single commodity. In 1906 about 70,000,000 tons were shipped, or excluding harbor traffic over 49,000,000, nearly 30 per cent of the total freight in American vessels. The largest part of this movement is that of the North Atlantic coast, but immense quantities of coal are moved on the Great Lakes and also down the Monongahela, Ohio, and Mississippi rivers. Coal is also an item of large relative importance on the canals. On the Pacific coast the movement of coal is of minor importance and is declining with the increased use of petroleum for fuel purposes.

Next to coal comes iron ore, aggregating over 41,000,000 net tons in 1906. Practically the whole of this movement is on the Great Lakes, where it is more than half of the total freight tonnage carried.

Stone and sand, with other building materials, are largely carried on the Atlantic and Gulf coasts and on the rivers of the Mississippi Valley, aggregating about 15,000,000 tons in 1906. These commodities, however, are, for the most part, carried over short distances, in contrast with the long-distance movement of coal and iron ore.

Lumber still represents an important part of the movement by water in all the districts. The census figures for 1906 are over 7,000,000,000 feet, or over 14,000,000 tons, but, lacking the movement by rafts, the statistics of these movements are incomplete. The transportation of grain and flour by water is of largest importance on the Great Lakes, where two-thirds of the 7,669,000 tons of these commodities reported for 1906 were carried. The domestic trade in grain on the Lakes shows some decline in recent years. Crude petroleum is moved by tank steamers in large quantities on the Atlantic, Gulf, and Pacific coasts.

The movement of phosphate and fertilizer, cotton, fruits, vegetables, tobacco, and naval stores, is mainly on the Atlantic and Gulf coasts. Ice moves chiefly from ports on the larger rivers of Maine and from the Hudson River to New York City and southern ports. This traffic has declined, probably due to the development of ice manufactories. Considerable crude phosphate rock is shipped from Florida and South Carolina, while other fertilizer materials and fertilizers are shipped from North Atlantic ports to the South. Naval stores and cotton are shipped mainly from the South Atlantic and Gulf to northern ports. Pig iron and steel rails are items of some importance on the Atlantic and Gulf coasts and on the Great Lakes.

THROUGH MOVEMENT ON THE ATLANTIC AND GULF COASTS.

The total traffic in American vessels on the Atlantic and Gulf coasts, as reported by the Bureau of the Census for 1906, amounted to 140,512,043 tons, including harbor traffic, and to 65,360,958 tons, excluding harbor movement. Most of this is domestic traffic. The Atlantic and Gulf coasts may be divided into three districts—North Atlantic, South Atlantic, and Gulf. There is a very large through movement between these districts, and also a large local traffic within the North Atlantic district and some local traffic in the other two districts.

Four Atlantic ports, sometimes called "the Atlantic portals"—Boston, New York, Philadelphia, and Baltimore—stand out conspicuously in coastwise as also in foreign commerce. Each of these is the distributing point for an important area and also the terminal of trunk lines of railroads connecting the agricultural and manufacturing sections with the seaboard. Among other ports of importance on the Atlantic and Gulf coasts are Portland, Providence, Wilmington, Del., Norfolk, Wilmington, N. C., Charleston, Savannah, Jacksonville, Mobile, New Orleans, and Galveston.

At the various ports traffic is specialized to a large extent. Some ports are identified with the movement of certain commodities, while at the larger ports special terminals are provided for different classes of traffic.

Coal is shipped from about a score of terminals at the five ports of New York, Philadelphia, Baltimore, Newport News, and Norfolk. Nearly 39,000,000 tons were shipped from these five ports in 1906, and 44,000,000 in 1907, over 60 per cent from terminals in and about the port of New York. Much of this moves only in the harbors and for short distances locally; but nearly half is delivered by barges at numerous points along the New England coast, over 1,000,000 tons going annually to New Haven, over 2,000,000 tons to Providence, and about 4,500,000 tons to Boston.

Lumber and naval stores are shipped from Jacksonville and Fernandina, Fla., Brunswick and Savannah, Ga., Charleston and Georgetown, S. C., Wilmington, N. C., and Norfolk and Newport News, Va., on the South Atlantic, mostly to points in the Middle Atlantic States. Receipts of southern pine at New York by water are over 450,000,000 feet. There is also a movement of eastern spruce from New England ports. Lumber is still carried to a large extent in sailing vessels, but steamships and steam-towed schooner barges are doing an increasing proportion of the business.

Cotton still occupies an important position in the Atlantic and Gulf coastwise trade. Recently there have been important changes in the relative rank of the different ports, and a general substitution of steam for sailing vessels in the carriage of this commodity. Galveston is the most important shipping point for cotton, both foreign and coastwise, but is closely followed in the coastwise trade by Savannah and Norfolk. New York is the principal receiving port, and Boston ranks second.

Crude and refined petroleum is shipped in large quantities from Port Arthur and Sabine Pass, Tex., amounting to over 10,700,000 barrels in 1906 and 8,700,000 barrels in 1907. There is also a large movement of refined oil from refineries adjoining New York and Philadelphia to New England and southern ports. Crude phosphate is shipped mostly from points in Florida and South Carolina; and fertilizers and fertilizer material are received in large quantities at southern ports from the North.

Another important movement is the interchange of general merchandise between the ports of New York, Philadelphia, and Baltimore and New England ports, and between the principal North Atlantic and the South Atlantic and Gulf ports. Other through movements include ice, fish, and granite from New England.

Trade with Porto Rico is carried on mainly from New York and New Orleans. Shipments to the United States consist mostly of sugar, with considerable tobacco and cigars and fruits. Shipments to Porto Rico include a large variety of manufactured goods.

NORTH ATLANTIC PORTS, RIVERS, AND CANALS.

Turning to the traffic within the three principal districts, above distinguished, it appears that much the greater part of this is in the North Atlantic district. This may be further divided into several subdistricts.

THE "GULF OF MAINE"—PORTLAND AND BOSTON.

This is the great indentation between Nova Scotia and Cape Cod. It is further indented by numerous bays and harbors and tidal rivers, the most important of which are Lubec Channel, Penobscot Bay, Kennebec River, Casco Bay, Portsmouth Harbor, Massachussetts Bay (including Boston Bay), and Cape Cod Bay. There is a considerable local movement in coastwise vessels between and along these bays and rivers. Boston and Portland are its most important ports. Portland has a considerable foreign commerce in grain and flour as well as a large coastwise trade carried chiefly by sailing vessels. Its total freight tonnage (domestic and foreign) in 1906 was 2,547,000, about one-half of which was coal. Boston, the chief port of New England, is one of the most important in the country, ranking second in foreign trade to New York, and third of the Atlantic ports in domestic trade. Coal is the largest item of coastwise receipts at Boston, amounting to 4,500,000 tons annually. Lumber receipts in 1906 amounted to 165,000,000 feet, more than two-thirds from the South. Much cotton is also received, and there is an important movement of general merchandise between Boston and other Atlantic ports north and south. The total traffic in American vessels at Boston, as reported by the census for 1906, was 7,420,574 tons, mainly coastwise.

SOUTH COAST OF NEW ENGLAND.

This coast has a series of sounds and bays furnishing protected or "inside" routes from New York to various ports in Connecticut, Rhode Island, and southeastern Massachusetts, where connection is made by rail with many industrial communities. The projected Cape Cod Canal will extend the inside route practically to Boston. The "outside" route south of Long Island is used in the trade from the Middle and South Atlantic ports.

New Bedford, on Buzzards Bay, has a large trade in coal, cotton, and whale oil. Narragansett Bay has several ports of some importance; Newport has a considerable trade in coal, lumber, and fish, and is also used as a harbor of refuge for vessels and barges. The city of Fall River, at the entrance to Taunton River, has an important coasting trade, large cargoes of coal and cotton being brought to its factories and also large quantities of steamboat freight (or general merchandise) for transshipment by rail to Boston and other points. Providence is of considerable importance in the coastwise trade, with regular lines of steamers to New York and Baltimore. Coal is the most important article received, but there is also a large volume of general merchandise and a movement of lumber, building materials, oil, and oysters. The total water-borne commerce for 1906 was over 3,000,000 tons, mostly domestic.

The commerce of Long Island Sound includes most of that to and from points in Narragansett Bay and a large part of the traffic from New York to the eastern coast of New England, besides receipts and shipments at the rivers and harbors along the Sound. The Thames River is a tidal stream for a distance of 15 miles from its mouth to Norwich. New London, on this river, has a large trade in general merchandise and coal. On the Connecticut River there is considerable commerce, both in steamers and barges, as far as Hartford, Conn., consisting mainly of coal, lumber, building materials, and miscellaneous steamboat freight. New Haven is commercially the most important harbor on Long Island Sound, with a large trade in coal and general merchandise, and a considerable movement of lumber, oysters and shells, steel billets, and petroleum products. The water-borne commerce in 1906 amounted to 2,300,000 tons, nearly all domestic. Bridgeport, a manufacturing city, has a large carrying trade by water. Less important points include Norwalk, Stamford, and Port Chester.

PORT OF NEW YORK.

The port of New York covers an extensive area, embracing both Upper and Lower New York bays, and their connecting channels, with a total water front of about 450 miles, of which about 125 miles are available for ocean steamships. New York is by far the most important center of water-borne commerce in the United States. Its foreign commerce is many times that of any other port, and nearly one-half the total foreign commerce of the country; and the coastwise and local harbor traffic is also many times that of any other port in the United States.

According to the census report for 1906, the total traffic of New York Harbor and adjacent points is as shown below:

	Shipments.	Receipts.	Total.
Traffic in American vessels (mostly coastwise):[a]	*Tons.*	*Tons.*	*Tons.*
New York City	8,598,374	17,507,906	26,106,280
Adjacent ports[b]	6,758,978	960,350	7,719,328
Total	15,357,352	18,468,256	33,825,608
Foreign trade (estimated)	14,963,162	10,049,167	25,012,329
Harbor traffic			55,131,418
Grand total	30,320,514	28,517,423	113,969,355

[a] So far as foreign trade is carried in American vessels, there is a duplication in the total, but much the greater part of the trade in American vessels is domestic trade.

[b] Hoboken, Jersey City, Newark, Perth Amboy, and South Amboy.

NEW YORK STATE INLAND WATERWAYS.

The inland water routes of the State of New York embrace the New York State canals and the Hudson River, which connect the Lakes with the port of New York by three routes, and Lake Champlain, which serves also Burlington, Vt. The commerce of the Hudson consists principally of lumber, grain, ice, building materials, including brick, and coal. There is also an extensive passenger traffic. There has been a considerable falling off in river freight at Albany from 5,071,000 tons in 1899 to 3,326,000 tons in 1906.

Up to 1855 the traffic on the New York canals was more than twice that of the railroads crossing New York State; until 1864 it was greater than that of the railroads, and in 1872 the canal traffic was one-third of the total traffic crossing the State. Since that time, and in spite of the abolition of canal tolls, there has been a steady decline until the past ten years. During the latter period canal traffic held its own in absolute amount, but the decline in the proportion of the total amount of traffic carried by the canals has been continuous, until at present the New York canals carry only 3 per cent of the total traffic across New York State. The total traffic on these canals in 1907 was 3,408,000 tons. Furthermore, in the last few years there has been an increase in local and way canal freight and a decline in through traffic, so that the way traffic now constitutes more than two-thirds of the total canal tonnage. Stone, lime, and coal together form the largest proportion of the total tons moved; grain, lumber, and wood have declined, but are still among the important articles.

The commerce of Lake Champlain consists principally of coal, pulp wood, building materials, and general merchandise.

DELAWARE BAY AND PHILADELPHIA.

The commerce of Delaware Bay and its tributaries and connecting canals is exceeded by only two or three local districts in the United States. It includes the extensive trade of Philadelphia, the important traffic of Wilmington, Del., and a considerable local movement on the Delaware River, its tributary streams, and a number of private canals.

The port of Philadelphia is on the Delaware River, about 86 miles above the Capes of the Delaware. Greenwich and Port Richmond, important shipping points for the coastwise movement of coal, are within the port of Philadelphia. Marcus Hook, with a great petroleum traffic, is near by. Philadelphia is well situated with reference to waterways, and connected with many inland points, as well as domestic and foreign ports. It is one of the great exporting points and also an extensive domestic commerce. Domestic shipments on the Delaware River for 1906, as reported to the United States engineers, amounted to 12,228,000 tons, and domestic receipts by water to 8,349,000 tons, a total of 20,577,000 tons. This total involves some duplication in the case of local movements. The census report gives the traffic in American vessels at Philadelphia for 1906 at 7,934,941 tons, excluding harbor traffic.

Wilmington, Del., has some foreign trade and a considerable domestic commerce by water, while the important shipbuilding and other manufacturing interests of the city are largely dependent upon the navigation facilities.

Connecting with the Delaware River are a number of tributaries and private canals—Cooper and Mantua creeks, Mispilion and Smyrna rivers, the Morris, Delaware and Raritan, Lehigh, and Delaware Division canals, the Schuylkill Navigation, and the Chesapeake and Delaware Canal connecting Delaware River and Chesapeake Bay. The traffic movement on these minor waterways is comparatively small, and that on the canals, except on the Chesapeake and Delaware Canal, has been slowly declining during the past ten years.

CHESAPEAKE BAY.

This is the largest indentation on the Atlantic coast. It is the center of a large foreign and coastwise movement converging at Baltimore, Newport News, and Norfolk, and there is also a large local movement on the bay and its numerous tributary rivers. The rivers of the eastern shore are of less general importance than those of the western, but are much used by local steamboats and small craft engaged in oyster dredging and local trade.

Baltimore is located on the north branch of the Patapsco River about 11 miles from its entrance into Chesapeake Bay. At this port are the terminals of a number of steamship lines operating to many points on the Atlantic coast and on Chesapeake Bay and its tributary streams. In the foreign trade Baltimore ranks fourth among the Atlantic ports in the tonnage of vessels. In the coastwise trade the largest volume consists of coal shipped north and south, amounting to 3,400,000 tons in 1906 and 4,070,000 tons in 1907. There is also an important movement of package freight. The total traffic in American vessels, according to the census, was 5,437,850 tons in 1906, nearly all coastwise.

Washington is the center of a considerable trade in coal, lumber, and ice, and a market for farm produce, oysters, and fish moved over the Potomac and Anacostia rivers. Traffic on the Chesapeake and Ohio Canal consist almost entirely of bituminous coal from Cumberland, Md., to Washington. There is also some traffic on the Rappahannock and York rivers.

SOUTH ATLANTIC PORTS AND RIVERS.

The water traffic within the South Atlantic divison is small as compared with that of the North Atlantic division. The greater part of the domestic traffic of South Atlantic ports is with the North. There is little or no local movement between these ports on the open sea, but the numerous rivers, bays, sounds, and lagoons along the South Atlantic seaboard have a considerable local traffic in the staple commodities of this section, with return shipments of plantation supplies and general merchandise. The inland manufacturing towns are generally supplied with coal by rail from local southern coal fields, and there is accordingly no large water movement of coal to southern ports for inland distribution. The foreign trade is carried very largely in tramp steamships, but the coastwise trade is sufficiently regular and large to employ regular lines of steamers to northern ports.

Norfolk and Newport News, at the southern end of Chesapeake Bay, near Hampton Roads, have a large and varied commerce, including important shipments of coal. The total water-borne commerce of Norfolk reported to the United States engineers for 1905 was 10,914,000 tons, and for 1906, 15,662,000 tons. The traffic in American vessels at Norfolk and Newport News, according to the census of 1906, was 10,488,576 tons, practically all coastwise.

Wilmington, the chief port of North Carolina, is on the Cape Fear River, about 27 miles above its mouth. Its total commerce by water for 1906 was about 800,000 tons, including logs and lumber rafted; traffic in American vessels was 267,139 tons.

The two principal ports of South Carolina are Georgetown, on Winyah Bay, and Charleston, at the confluence of Cooper and Ashley rivers. The commerce of Georgetown for 1906 amounted to 393,000 tons. Charleston has some foreign and considerable coastwise trade, but has declined as a cotton port. The foreign and coastwise commerce for 1906 amounted to 835,000 tons; traffic in American vessels, 718,680 tons.

Savannah, on the Savannah River, about 15 miles above the entrance, is the principal port of Georgia, and is one of the most important South Atlantic seaports for the shipment of cotton, lumber, and naval stores, which are received from the interior by rail and to some extent by river. The traffic in American vessels in 1906 was 1,490,363 tons. Brunswick, Ga., is also an important shipping point for lumber.

On the Atlantic coast of Florida are the two important ports of Fernandina and Jacksonville, with a total commerce by water in 1906, as reported to the United States engineers, of 955,000 and 2,115,000 tons, respectively. The census gives the traffic in American vessels at Jacksonville at 993,566 tons. At the southern end of the peninsula there is a small movement centering at Miami.

RIVERS AND OTHER INLAND ROUTES.

There is considerable traffic on the James River. Through the Dismal Swamp and Albemarle and Chesapeake canals there is some movement of forest products and other traffic between Norfolk and the rivers and sounds of North Carolina. There is also considerable local traffic on the tributaries of Albemarle and Pamlico sounds and some on the Cape Fear River. In South Carolina there is a local movement of some importance on the Waccamaw, Pedee, and Santee rivers. There is also some local traffic, mostly of lumber, on the Savannah, Altamaha, and Ocmulgee rivers in Georgia, and a considerable movement on the St. Johns River in Florida. The inside coast routes have but little traffic.

GULF PORTS AND RIVERS, EXCLUSIVE OF THE MISSISSIPPI.

PRINCIPAL GULF PORTS.

The chief Gulf ports, in the order of importance, are New Orleans, Galveston, Mobile, Port Arthur, Pensacola, Tampa, and Key West. Each has considerable export and coastwise trade moved by steamship lines and sailing vessels. Of coastwise shipments, the greater part are to northern ports, the remainder representing a local movement between Gulf ports.

Several steamship lines run from Mobile to ports in Central America, Mexico, and Cuba, and a number of tramp steamers to Europe. A steamship line operates between Mobile and New York, and several local lines run to neighboring Gulf ports and river ports, including Montgomery. Important bulk commodities handled at Mobile are lumber and timber, cotton, and coal. The total commerce reported by the United States engineers for 1906 was 1,373,000 tons, of which 302,000 tons were coastwise. Traffic in American vessels was 363,000 tons, according to the census report.

New Orleans is on the Mississippi River about 100 miles from the Gulf. The port facilities for handling cargoes are excellent. Rail lines from all directions converge here, and there are regular lines of steamers to Tampa, Baltimore, and New York, and also to Mexico, Central America, Panama, Habana, Porto Rico, and European ports, besides many tramp vessels. In the foreign trade, New Orleans is an important point of import for the products of Central and South America and the West Indies. In exports it is also of much importance, particularly in the cotton trade. New Orleans is a natural port of export for cotton and grain. In the coastwise trade shipments are made up of cotton, rice, citrus fruits, and other agricultural products, lumber, sugar, molasses, etc., the most important traffic being with New York. The total water-borne commerce of New Orleans (foreign, coastwise, and river) for 1906 was 5,702,000 tons, three-fifths of which was foreign trade. The coastwise movement reported to the United States engineers amounted to 694,000 tons. According to the census, the foreign and coastwise traffic in American vessels at New Orleans for 1906 was 1,924,484 tons. The river commerce of New Orleans will be considered in connection with the Mississippi River.

Galveston is the principal port of Texas, and the second Gulf port in importance. According to the United States engineers, it has the largest coastwise trade of any of the Gulf ports, amounting in 1906 to 832,000 tons. The census reports the traffic in American vessels for 1906 at 1,695,897 tons. Several important lines of steamers run regularly to Atlantic ports, and it also has a large foreign trade in cotton, cotton-seed products, sugar, coal, and general merchandise.

TRIBUTARY RIVERS.

The maritime commerce of the Gulf ports is fed to some extent by tributary rivers. Of these, the most important are the rivers of the Alabama system, including the Mobile, Alabama, Coosa, and Tombigbee. Other Gulf tributaries with local traffic of some importance include the Withlacoochee, in Florida; the Apalachicola and its tributaries, in Florida and Georgia; the Pascagoula, Leaf, and Chickasahay, in Mississippi; the Chefuncte and Calcasieu rivers and bayous Plaquemine and Teche, in Louisiana, and the Neches, Sabine, and San Jacinto rivers, in Texas.

THE GREAT LAKES AND CONNECTING WATERWAYS.

The principal characteristics of Lake commerce are the preponderance of eastbound over westbound shipments and the fact that the traffic is mainly in a few commodities—iron ore, grain, coal, and lumber. There is a considerable movement of miscellaneous and package freight, both local and through, but it is small compared with the enormous bulk-freight traffic in the crude products of contiguous mines, forests, and grain fields.

Through traffic constitutes the greater part of the total freight movement. The main course of this lies between the western extremity of Lake Superior and the southern shore of Lake Erie.

The Lake traffic was not reported as a whole prior to 1889, when, according to the Census, the domestic traffic amounted to 25,266,974 net tons. The domestic traffic amounted to 45,000,000 tons in 1901, and in 1907 to more than 80,000,000 (shipments 83,507,000 and receipts 81,124,000 net tons).

MOVEMENT OF COMMODITIES.

Iron ore and coal form by far the greater part of the Lake traffic, and furnish together 98 per cent of the total increase from 1905 to 1907. The movement of lumber during these years has declined in importance; other traffic, outside of ore and coal, has remained about stationary.

Since 1890, with the development of the Lake Superior mines, the United States has taken first rank among the world's iron producers. Of the total domestic production of iron ore, approximately 80 per cent was transported by way of the Great Lakes (41,000,000 net tons in 1906 and 45,500,000 net tons in 1907), constituting in some years more than half of the total domestic Lake traffic.

Next in volume to iron ore, and first in the westbound Lake traffic, is the westbound movement of coal. This was over 21,000,000 tons in 1907, representing about a fourth of the domestic Lake traffic.

In the movement of flour and grain (eastbound) there is active competition between the Lake and all-rail routes, and with the decline in export trade the domestic movement on the Lakes has remained practically stationary in recent years, at about 150,000,000 bushels of grain and 1,300,000 tons of flour. There has been an increase of traffic from American ports to Canada and also between Canadian ports.

The traffic in logs and lumber is decreasing in volume and still more in relative importance. Nevertheless, it still constitutes one of the leading items.

Some of the less important forms of traffic are the movement of copper, salt, pig iron, and package and miscellaneous freight. About 100,000 tons of copper ore are annually shipped, mainly from the copper district in the Upper Peninsula of Michigan. Salt is shipped by Lake in considerable quantities from Manistee and Ludington, Mich., and in smaller quantities from Buffalo and other points. Pig iron moves in small lots between a considerable number of ports. Package and miscellaneous freight forms about a tenth of the total traffic.

TRAFFIC BY LAKES AND PORTS.

Lake Superior shows the largest volume of shipments of any of the Great Lakes, domestic shipments aggregating over 40,000,000 tons in 1906. About 65 per cent of the total traffic of the Lakes passes in or out of Lake Superior through St. Marys Falls canals. Lake Erie has the largest receipts (43,600,000 tons in 1906 and 47,000,000 in 1907 in the domestic traffic), is second in volume of shipments (18,450,000 tons in 1906), and has the largest proportion of the total traffic. Lake Michigan ranks third, but has the largest amount of local traffic.

Notwithstanding the large number of Lake ports, about a dozen ship and receive 80 per cent of the water-borne traffic. Duluth-Superior is the most important port for shipments and has the largest water-borne traffic of any of the Lake ports, aggregating over 29,000,000 tons in 1906, mainly ore, grain, and coal. Chicago and Milwaukee are among the leading ports, both for shipments and receipts. The Lake commerce of Chicago amounts to about 10,000,000 tons annually, and that of Milwaukee to 6,000,000 tons. Buffalo and Cleveland are also ports of first importance, both in the volume and in the variety of their commerce, and Buffalo has the largest receipts of any of the Lake ports. The Lake commerce of Buffalo for 1906 exceeded 15,500,000 tons (domestic traffic 14,345,000 tons), and, including canal traffic, the total water-borne commerce of Buffalo was over 17,320,000 tons. The Lake commerce of Cleveland for 1906 was 12,247,000 tons (domestic traffic 11,670,000 tons). Other important but more specialized ports include Two Harbors, Ashland, and Marquette, on Lake Superior, and Escanaba, on Lake Michigan, for shipments of ore; Toledo, Ashtabula, Lorain, Conneaut, and Erie, on Lake Erie, for receipts of ore and shipments of coal, and Tonawanda for receipts of lumber.

MISSISSIPPI RIVER AND TRIBUTARIES.

This is the greatest of our inland-river systems, and belongs in a class by itself. It includes not only the Mississippi itself, but also the Ohio, Missouri, Illinois, Arkansas, Ouachita, Red, and Yazoo rivers, with their tributaries, together with a number of other rivers of minor importance. The state canals of Ohio and Illinois are also connected with this system.

The commerce of these various waterways has not kept pace with the general industrial progress of the Middle West. The methods of competition of railroads and the limitations imposed in the competition of boat lines with railroads by the physical characteristics of the rivers in their present condition are the prime causes that have contributed to the decline of river traffic. The boat lines have been handicapped in their competition with rail carriers by the tortuousness of the channel and by the limited and varying depths, causing at times a practical suspension of traffic. They have made little advance in methods for a long time, while the railroads have made important improvements both in physical conditions and in business methods. These improvements, adapted to the changing needs of commerce, in the absence of corresponding improvements in the rivers, have resulted disastrously to boat lines. To-day the principal long-distance shipments by river consist of coal from the Ohio and its upper tributaries to lower Ohio and Mississippi River points, and of logs, lumber, and railroad ties on the whole system, the bulk of the traffic moving downstream.

OHIO RIVER AND TRIBUTARIES—PITTSBURG.

The Ohio with its tributaries has now the most important river traffic in the country. Coal carried in barges from the Monongahela and other tributaries forms the largest part of this movement. Lumber, sand, and gravel are other bulk commodities moved in barges. Logs and timber are rafted in considerable quantities. There is also a considerable amount of miscellaneous and manufactured articles transported in mixed cargoes on packet steamers. In the latter movement local traffic is relatively more important than formerly, owing to the disappearance of through packet lines.

Pittsburg has now the largest river commerce of any inland city in the country. Coal from the Monongahela is received in large quantities, and there is a large harbor movement of sand. Receipts and shipments by river for 1906, according to the Census, amounted to 6,854,575 tons, and including harbor traffic to 8,956,697 tons. Reports to the United States engineers show a total traffic in Pittsburg Harbor for 1906 of 12,927,975 tons.[a] At Cincinnati receipts and shipments by river for 1906 amounted to 2,363,215 tons; at Louisville to 1,203,727 tons, the total river traffic at Louisville being reported to the United States engineers at 1,436,674 tons. Other places of importance are the Ohio and its tributaries include Wheeling, Parkersburg, Marietta, and Evansville; Nashville, on the Cumberland River; Knoxville, Chattanooga, and Florence, on the Tennessee River, and Cairo, at the junction of the Ohio and Mississippi. Traffic on the Ohio state canals is unimportant.

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[a] This probably includes the movement of coal from the Monongahela River to points on the Ohio below Pittsburg, which simply passes through Pittsburg Harbor.

The traffic of the Ohio River and its more important tributaries for 1906 is shown in the following table:

Rivers.	U. S. Census.[a]		U. S. engineers,[b] total traffic.
	Shipments.	Receipts.	
Monongahela	8,925,923	545,716	11,817,128
Muskingum	13,826	11,073	28,433
Little Kanawha	11,239	6,953	70,289
Kanawha	975,031	63,832	1,227,703
Big Sandy	1,776	4,887	205,452
Kentucky	....	....	184,244
Green and Barren	305,144	80,902	416,906
Wabash	42,427	30,537	....
Cumberland	348,697	178,951	558,250
Tennessee	678,501	472,759	1,578,700
Ohio	3,142,097	12,296,037	11,427,784
Other[c]	782,144	345,299	....
Total	15,226,805	14,036,946	....

[a] Excluding logs and rafted lumber.
[b] Including logs and lumber.
[c] Allegheny and Kentucky rivers.

The statistics of the United States engineers give the total traffic on each river, and a total of these figures would duplicate the traffic moving from one stream to another. Shipments and receipts on the whole Ohio system represent practically the same traffic. The total shipments should indicate the total traffic of the Ohio system, but the census figures do not include the movement of rafted logs and lumber, and including this and harbor traffic (2,354,000 tons), the total shipments on the Ohio and tributaries were probably about 20,000,000 tons.

The census figures show a considerable decline on practically all of these rivers except the Monongahela from 1889 to 1906, and a small decline on the Ohio system as a whole; but the principal decrease indicated is in lumber, the rafted movement of which was partly reported in 1889 and not in 1906. Including coal, the total traffic has probably increased, but shipments of miscellaneous merchandise decreased from 2,819,000 tons in 1889 to 1,314,000 tons in 1906.

UPPER MISSISSIPPI,—ST. LOUIS.

The commerce of the upper Mississippi and its tributaries is relatively unimportant and declining. It consists mainly of local traffic, largely of rafted logs and lumber, and of sand. Traffic on the canals connecting the Mississippi with the Great Lakes is even less important. St. Louis is a converging point for traffic from the upper Mississippi and to a slight extent from the lower Mississippi, the Missouri, the Illinois, the Ohio, the Cumberland, and the Tennessee rivers.

But river commerce at St. Louis has declined steadily during the past fifteen years. The St. Louis Merchants' Exchange reports shipments and receipts of 1,266,000 tons in 1890, of 757,000 tons in 1900, and only 417,000 tons in 1906. The census reports the total shipments and receipts in 1906 as 743,981 tons, including 309,000 tons of sand and stone. The harbor traffic is reported at 969,000 tons.

LOWER MISSISSIPPI,—MEMPHIS AND NEW ORLEANS.

This includes the river from St. Louis to New Orleans. Here the most important through traffic is coal from the Ohio. At Memphis, Greenville, Vicksburg, Natchez, and other places there is some river traffic in coal, lumber, and plantation products and supplies. Memphis is one of the few ports on the Mississippi showing an increase in river traffic in recent years. The traffic in 1906 was 857,000 tons, and that at Vicksburg 375,000 tons. At New Orleans the receipts of bituminous coal by river from the Ohio are estimated at about 1,200,000 tons annually. Cotton, cotton seed and its products, sugar, molasses, and rice are also received at New Orleans from various points on the lower Mississippi and other streams in this territory. There is also considerable traffic in crude petroleum from Louisiana, on the lower Mississippi. The various short canals more or less directly connected with the New Orleans river trade are commercially of comparative unimportance. The total river traffic at New Orleans in 1906, according to the census, was 1,144,113 tons, and according to reports to the United States engineers was 1,666,000 tons.

Below is given a summary of the traffic reported on the several sections of the Mississippi and some of its tributaries (other than the Ohio) for 1906:

Rivers.	U. S. Census.[a]		U. S. engineers, total.[b]
	Shipments.	Receipts.	
	Net tons.	*Net tons.*	*Tons.*
Upper Mississippi	595,885	597,025	5,282,319
Illinois	105,826	106,002	
Missouri and other tributaries	1,056,390	1,051,474	573,348
Total	1,758,101	1,753,501	5,855,667
Lower Mississippi	[c]2,329,350	3,487,137	
St. Louis to Cairo			458,016
Cairo to Memphis			1,719,893
Memphis to Vicksburg			2,355,901
Vicksburg to New Orleans			2,554,396
St. Francis	(d)	(e)	151,015
White	43,933	25,433	127,812
Arkansas	24,994	35,671	104,593
Yazoo	108,357	62,325	227,611
Ouachita and Black of Louisiana	25,136	16,998	171,952
Red	14,417	8,481	112,273
Other rivers		[e]102,401	
Total	2,546,187	3,740,646	

[a] Excluding logs and rafted lumber.

[b] Including logs and lumber.

[c] Including the Atchafalaya, Black of Arkansas, Black Bayou, Lafourche, Macon Bayou, St. Francis, and Tensas.

[d] Included in lower Mississippi.

[e] Included in other rivers.

The traffic reports to the United States engineers give each stream and the sections of the lower Mississippi separately, and a total of these would include duplications to a large extent. The Census figures, on the other hand, do not show the movement of logs and rafted lumber, while the shipments on the lower Mississippi do not include the coal movement from the Ohio. The shipments on the upper Mississippi and the receipts on the lower Mississippi indicate a total traffic on the Mississippi of 5,500,000 tons, excluding logs and rafted lumber and harbor traffic. Including rafts and harbor traffic, the total movement on the Mississippi and tributaries, exclusive of the Ohio system, is probably about 12,000,000 tons.

For the entire Mississippi system, the total shipments and receipts from one port to another, according to the Census as shown below, amounted to 19,531,093 tons in 1906. Including rafts, the movement would be about 25,000,000 tons, and including also harbor traffic (5,190,291 tons) the total would be about 30,000,000 tons.

	Shipments.[a]	Receipts.[a]	Harbor movement.
	Net tons.	*Net tons.*	*Tons.*
Ohio River system	15,226,805	14,036,946	2,354,147
Upper Mississippi system	1,758,101	1,753,501	482,099
Lower Mississippi system	2,546,187	3,740,646	2,354,054
Total	19,531,093	19,531,093	5,190,291
Carferries (estimated)			6,905,597

[a] Excluding rafts.

The Census reports show a large decrease in traffic on both upper and lower Mississippi and for the whole Mississippi system from 1889 to 1906. The extent of this decrease is, however, somewhat exaggerated by the omission of rafted logs and lumber from the statistics of 1906, although these were partially included in 1889, and the largest decrease indicated is in the movement of lumber. But the movement of grain, cotton, and miscellaneous merchandise has fallen to small proportions; and while coal, petroleum, and sand have increased, the total traffic on the whole system is undoubtedly a good deal less than in 1889. The most important increase has been the coal traffic of the Monongahela; there has been an increase of miscellaneous freight on the Cumberland, the Tennessee, and the Yazoo rivers, and the total volume of traffic on the Yazoo has increased to some extent.

PACIFIC COAST AND TRIBUTARIES.

The traffic of the Pacific Coast States is still mainly in raw materials and agricultural products, such as wheat and its products, barley, live stock, fruits, hops, and the products of forests and streams. A recently developed traffic has followed the discovery of oil fields in southern California. Generally speaking, the articles mentioned, with the wool, live stock, and minerals of the Rocky Mountain States, constitute most of the traffic in this territory, either coastwise, by river, or by rail.

The important political events of the past few decades have increased considerably the water-borne commerce of the Pacific coast. The mining and commercial development of Alaska, as well as the demand on the part of oriental countries for the products of the West, have aided in this development, as have also the extension of railroad facilities and the introduction of new crops and industries. One serious drawback has been the scarcity of coal, which is now being partially met by the use of oil for fuel purposes.

The principal bulk coastwise shipments are products of the forests and petroleum. Lumber is moved in large and increasing quantities from Puget Sound, the Columbia River, and the coasts of Washington, Oregon, and upper California. Cargo shipments from Washington and Oregon have increased from 398,000,000 feet in 1894 to 1,443,000,000 feet in 1907; and, including upper California, the total cargo shipments for 1907 were 1,880,000,000 feet. Most of this movement is coastwise.

Petroleum is shipped, mainly in tank steamers, from Port Harford and other points between San Diego and San Francisco to coast points and Hawaii. Shipments in 1906 amounted to nearly 11,000,000 barrels, or about 1,700,000 tons. Some grain moves coastwise from Oregon and Washington to San Francisco, receipts at the latter point amounting to 3,848,000 bushels in 1906 and about the same in 1907. There is a considerable movement of coal by water from Puget Sound and Coos Bay (Oregon) to other Pacific coast points, largely to San Francisco, in vessels employed also in carrying lumber and general merchandise, but there is no regular and exclusively coal carrying fleet. Shipments of coal from Seattle and Tacoma amounted to 605,000 tons in 1906 and 701,000 tons in 1907. Receipts of coal at San Francisco (including imports from British Columbia and Australia) amounted to about 800,000 tons in each of these years.

Traffic between the Pacific Coast States and Alaska and, of course, Hawaii, is carried by water. Most of the trade to Alaska is from Puget Sound ports, steamship companies operating principally from Seattle. The largest share of the Hawaiian trade is from San Francisco, but there is also a considerable amount from Puget Sound and some vessels from the Atlantic coast.

There is a considerable trade between San Francisco and Puget Sound and the Philippine Islands carried by way of Hongkong, as there is no direct line from the Pacific coast to Manila; but the larger part of the trade with the Philippines is from New York, and a notable part of the return movement comes to Boston.

The four leading ports on the Pacific are San Francisco, Portland, Seattle, and Tacoma. Each is the center of numerous water routes and the terminus of transcontinental lines of railroad. From San Francisco the shipments in American vessels in 1906 amounted to 1,656,614 tons, from Seattle 856,988 tons, from Portland 492,573 tons (total domestic traffic by water 648,497 tons), and from Tacoma 270,256 tons. On the Pacific coast generally a larger proportion of the trade in American vessels is foreign trade than on the Atlantic coast. Grays Harbor and Humboldt Bay are important lumber shipping points; Port Harford, in San Luis Obispo Bay, is an oil port; the ports of Los Angeles receive large quantities of lumber and general merchandise, and San Diego has a considerable trade by water.

There is some local traffic on several groups or systems of rivers on the Pacific coast. On the tributaries of Puget Sound there is a large local movement of logs, aggregating 1,200,000,000 feet in 1906; and a small amount of local traffic of other kinds. On the Columbia River there is some traffic on the upper river and tributaries, and a larger river commerce below Portland, including an extensive movement of logs. On the short rivers and bays along the coast of Washington, Oregon, and upper California, there are large numbers of logs moved and a small amount of general traffic. The most varied river traffic is on the rivers of central California, where there is a considerable movement of grain, flour, and general merchandise, centering at Sacramento and Stockton.

Part III.—PORT TERMINALS.

The control of port terminal facilities forms the key to the important question of effective competition with railroads on the part of water lines; but to a very great extent the water fronts of important ports, or the most available parts thereof, are so controlled by railroads and their allied water lines as practically to eliminate effective competition. In many cases the railroads have acquired water-front property by purchase or condemnation because it was the most available location for their tracks and terminals, or because they possessed greater foresight than other investors as to the potential value of such property; in other cases, however, railroads have gained possession of valuable water fronts by encroachments, which have sometimes ripened into legal titles through the neglect of municipalities or other riparian owners.

Railroad control of city water fronts is very extensive. An important case of such control is the occupation of the lake frontage of Chicago by the Illinois Central Railroad. Practically all the water lines operate in the narrow and tortuous Chicago River, impeded by bridges above and until recently by tunnels below. Among other noteworthy cases of railroad control of a city's water front may be mentioned Buffalo, N. Y.; Cleveland, Ohio; Jersey City, N. J.; Norfolk, Va.; Mobile, Ala.; Oakland, Cal.; and Tacoma, Wash.; while at many points along the Ohio and Mississippi rivers the railroads occupy long stretches of water front, including not only the areas needed for their own terminal facilities, but miles of river bank which, but for the adverse possession of the railroads, might readily be acquired and utilized by their would-be competitors by water.

Control of terminal facilities by railroad and industrial interests and steamship lines is so extensive at some ports as to make it difficult for independent boats or occasional sailing vessels to obtain landing privileges. In some cases, for example, a particular navigation line has acquired all of the water front affording direct access to rail terminals, or a number of lines may together control all the conveniently available wharves. At several ports on Long Island Sound the several steamboat lines controlled by the New York, New Haven and Hartford Railroad have acquired possession of the available wharves to such an extent that independent lines and even shippers have experienced great difficulty in obtaining terminals.

It is not necessary, however, for the railroads to own great stretches of water front in order to control the terminal situation at important ports. So far as through traffic is concerned, a railroad need only have a wharf at the point of transfer between rail and water carriers in order to have a decisive advantage over its competitors by water. It is not the wharf alone that gives this advantage; a wharf connecting a rail line and a water line is of much more importance than a wharf without rail connections. Railroads having wharves in such strategic positions commonly "absorb" the wharfage charges in their through rail-and-water rates, or, in other words, make no additional charges for wharfage on through traffic going or coming over their own lines. A water line can not so well afford to offer free wharfage, especially if it has to lease a wharf or pay wharfage charges itself; and in any case, unless the wharf has rail connections, the freight must be taken to and from the wharf either by lighters or by trucks, involving additional expense. Where a railroad comes down to the wharf, lighterage is unnecessary, in the case of goods going over that line at least; and as railroads commonly have switches to many of the important industries along their lines, freight cars can usually be left at the door of the factory, mill, or jobbing house to which it is consigned. Thus, railroad control of terminals results in a decided disadvantage to independent all-water lines, and in procuring the shipment of freight as far as possible by rail, even when it could go partly to its destination by water.

A port which allows its wharves to fall mainly into the hands of railroads is likely to find its local shipping business injured thereby; for railroad control of water terminals at a port apparently tends to result in their use for transfer of through freight between cars and vessels to the exclusion of business originating at or destined to the port itself. A legislative commission recently appointed to investigate conditions at the port of New Orleans, after visiting the ports of Galveston, Mobile, Pensacola, and Savannah, at all of which the terminals are in the hands of railroads and private owners, reported that the shipping business at all these ports is simply a matter of transferring freight from cars to ship; and that the local trade by water of Galveston and Savannah is gone. An extreme case of the use of terminal facilities by a railroad to secure traffic for its line, with the result of creating a monopoly, is that of a pier at Galveston erected by the Southern Pacific Terminal Company (affiliated with the Southern Pacific Railroad) and leased to a shipper of cotton-seed products, one of the conditions of the lease being that the lessee must route all his shipments over the lines of the terminal company. The lease being at a fixed rental per annum, when the lessee's shipments exceed a certain amount a year his terminal charges per hundred pounds were less than the regular wharfage charge to other shippers, and the result was practically to center in him all the cotton-seed product export business of Texas and adjoining States.

The Interstate Commerce Commission has declared this arrangement unlawful in that it gave the lessee undue preference and advantage in exempting him from the published wharfage charges and giving him the exclusive use of wharf space such as other shippers could not obtain. Another way in which railroads controlling wharves have sometimes used them so as to secure undue advantages is by denying their use to independent or competing vessels, even on payment of wharfage charges, while granting their use free of charge to vessels handling traffic in connection with the controlling railroad on through bills of lading, and so bringing traffic to that road. To some extent such discriminations have been declared illegal by the courts, which have held that wharves, at least when they are railroad terminals, are so affected with a public interest that their owners are bound to extend their facilities to all on equal terms, if they hold themselves at all as public wharfingers. This rule, however, will not prevent a railroad owning a wharf from using it solely for its own carrying business in connection with its own lines;[a] nor has it been so universally applied as wholly to do away with the granting of exclusive wharf privileges to steamship lines. At Boston each of the great ocean steamship lines has the exclusive use of a pier belonging to a railroad company; while at Philadelphia the complaint is made that the railroads will not allow lighters to come to their piers, but practically require all the goods coming to their piers to go over their own lines.

There are several ports on the Great Lakes and a few on the Atlantic coast north of Savannah at which the terminals are controlled by railroads and used almost wholly for the transfer of through freight between cars and vessels; but at some of them, especially the smaller places, the question of decay of the local trade has never arisen because the shipping industry has been created by the railroads in connection with their through business. There are advantages both to the railroads and to the general public in the establishment of such transfer terminals at points outside of the large cities, where the price of land is low enough to make plenty of warehouse room feasible, and where, by avoiding the congested city terminals, transfers can be effected with much greater expedition. Congestion of traffic is complained of at many ports as an evil of no small magnitude, and in several cases steps are now being taken by public or private agencies to increase the available wharf facilities.

PUBLIC OWNERSHIP AND CONTROL OF WATER FRONTS AND WHARVES.

Public ownership of wharves is much less common in this country than in Europe, but a number of American cities have owned wharves from early days, and in recent years several cities have more actively undertaken the development of the commercial water front.

Public ownership of the water front alone is not necessarily effective in preventing its practical control by transportation interests. The constitution of the State of Washington provides that the land below the line of high tide shall never be alienated by the State. Yet there is no indication in the data available on this point from the State of Washington that this has prevented the railroads from getting large control of the commercial water fronts; every indication points to extensive railroad control. The ineffectiveness of the Washington system is perhaps due in part to the provision of law which gave riparian owners preference in granting leases of water-front areas, and partly, no doubt, to the provision which limits the rentals to an amount less than the real rental value of such locations.

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[a] Dutton v. Strong, 1 Black, 23; Indian River Steamboat Company v. East Coast Transportation Company, 28 Fla., 387; West Coast Naval Stores Company v. L. & N. R. R. Co., 121 Fed. Rep., 645.

Even public ownership of wharves and other improvements on the water front is not always effective as a means of retaining actual control. The New York system of partial municipal ownership has been criticised on the ground that by leases of wharves for long terms of years the city practically loses control of important parts of its wharf system, so that vessel owners who neither own nor lease wharves have to obtain landing privileges from the lessees.

Short-term leases are not commonly considered practicable where the lessee is expected to erect expensive improvements, such as fireproof sheds, but provision is sometimes made for compensation for such improvements, after allowing for depreciation. Another plan permitting short leases is the construction of all improvements on public wharves at public expense; though in some cases this may not be financially feasible. San Francisco partly solves this difficulty and also avoids losing actual control of its water front by leasing each new wharf for a short period, never exceeding fifteen years, to such bidder who will take a lease for the smallest number of years, the said bidder to construct at his own expense a wharf of a specified character. At the expiration of the term agreed upon the wharf reverts to the public and becomes a public wharf. On the whole the system seems to have proved satisfactory. At any rate, the public is gradually acquiring valuable wharf properties, practically without expense in the long run. Bond issues are sometimes necessary at San Francisco as elsewhere, for the lessees pay their rentals in annual instalments extending throughout the term of their leases.

COORDINATION OF TERMINAL FACILITIES.

In several of the most important cities of the United States, local shippers are handicapped by lack of convenient access to rail and water transportation facilities, more especially the latter, owing to the haphazard distribution of terminals and the lack of coordination between them. Such disadvantages may more than offset the advantage of nearness to the place of production or sale. Many large cities have belt or terminal railways connecting the trunk railroad terminals; and New Orleans has just completed a public belt railroad connecting both rail and water terminals which is to be operated by public officials. This belt line consists of more than twenty miles of double track, with switches at all the wharves, all the freight depots, and all the more important industries, thus eliminating drayage to the greatest possible extent. A public belt railroad is also operated on the San Francisco water front. Much more common are switching tracks controlled either by a wharf company, as at Galveston and at the Bush terminal in South Brooklyn, or by a trunk railroad, as at Boston. At Philadelphia and Buffalo, however, special precautions have been taken to prevent the terminal railroads connecting the wharves from falling wholly into the control of any single railroad; at Philadelphia, by turning a majority of the stock over to the board of trade and the commercial exchange, as trustees for the commercial interests of the city; and at Buffalo, where the terminal line is owned jointly by two trunk lines, by a franchise requiring equal facilities to be provided for all companies and individuals desiring them.

MECHANICAL LOADING AND UNLOADING APPLIANCES.

Bulk cargoes consisting of such homogeneous materials as coal, ore, or grain lend themselves most readily to mechanical loading and unloading; and it is where such special traffic is greatest in amount that mechanical appliances for loading and unloading vessels find their fullest development. It is said, probably without exaggeration, that no other traffic in the world has arrangements for handling so perfect as has the iron-ore traffic on the Great Lakes and the connecting railroads. Ore trains direct from the mines are run out on high piers or trestles at Duluth and other upper lake ports and unloaded by gravity into pockets from which the ore flows into the steamers alongside the piers. At the ports of discharge on the lower lakes the ore is lifted from the holds of the vessels by electric cranes carrying several tons at a load, and often deposited directly in railroad cars waiting to take it to its destination. Thus vessels carrying over 10,000 tons of ore are often loaded in a few hours, and unloaded in less than a single working day. A vessel often receives its return load of coal without changing its berth, both the loading and the unloading being again effected by mechanical devices. At the coal ports on the Atlantic coast and along the Ohio River and its tributaries coal is loaded mainly by gravity from "tipples" or trestles extending out over the water, while at Cincinnati and New Orleans it is unloaded and elevated to cars or steamships by mechanical means.

Very complete appliances for loading and unloading grain at points of transfer between rail and water lines are provided by the grain elevators, which serve also as storage warehouses for longer or shorter periods, and have machinery for mixing and often for cleaning grain.

The ore trestles at the head of the lakes are owned by the railroads, as are also the receiving appliances at lower lake ports except where industrial concerns are located on the lake front and have their own unloading machines.

Coal tipples in the mining regions are commonly owned by coal-mining companies; those at ports of transshipment, on the Great Lakes and elsewhere, either by coal companies or by railroads; while at distributing points the coal is unloaded mainly at wharves belonging to coal companies, some of which, however, are themselves controlled by railroads.

Grain elevators are owned sometimes by railroads and sometimes by grain dealers. In many cases railroad elevators are leased, and are operated by grain dealers as lessees. At Buffalo there is an elevator pool composed of the elevators having both rail and water connections, except those belonging to railroad companies, which latter were active in its organization, but were forced out by the amendment to the interstate commerce act extending to terminal facilities the prohibition against pooling. The railroads still act in harmony with the pool, however, and there seem to be good reasons for believing that the pool is really an agency through which the railroads practically control the elevator situation at Buffalo.

At New Orleans the United Fruit Company has several machines for unloading bananas from its vessels by means of endless canvas belts, consisting of a series of pockets, which can also be employed in loading or unloading any merchandise put up in sacks or small packages.

In marked contrast with the complete arrangements provided by railroads, coal companies, and other concerns for handling ore, coal, grain, and tropical fruits, is the almost complete lack of mechanical appliances for loading and unloading cargoes of general merchandise at American ports, whether the wharves are under railroad, private, or public control. In loading or unloading a large general cargo, the vessel's own steam winches are employed, together with skids, to deposit the freight on the wharf at the vessel's side or to lift it from that point into the vessel's hold; but the movement of freight on the wharf itself is usually effected with hand trucks. At European ports it is common to find the wharves equipped with powerful cranes moving on tracks paralleling the water's edge, so they can be brought into requisition at any point. There is an obvious advantage in the use of such machinery on the wharf instead of the vessel's own winches, because the wharf machinery has a longer reach landward, and can be used in loading railroad cars direct from the vessel or in storing freight in a warehouse. That American stevedores are content to do with comparatively primitive arrangements is one of the most curious facts connected with American shipping.

Along the Ohio River the rise and fall of the water is too great to admit of the use of fixed wharves, and their place is therefore taken by floating wharf boats which rise and fall with the water. To the inconvenience of this kind of landing is added, at most points, the difficulty of hauling freight up the steep banks of the river. The same is true of some places on the lower Mississippi.

PORT CHARGES.

At New York and some other ports complaints of high port charges are frequently heard. At New York, indeed, the decline of commerce of the port is attributed largely to the high charges for pilotage, towboat charges, wharfage, lighterage, and the expense of discharging cargo. The United States tonnage tax on vessels from foreign ports, together with custom-house and quarantine charges, and the local health officer's and port warden's fees, make up the other port charges, commonly so called. It is difficult to keep wharfage charges low where land, and consequently wharf room, is as valuable as it is on Manhattan Island.

Where the wharves are publicly owned, as a rule, they are not made a source of revenue to any considerable extent, the usual policy, in theory at least, being to reduce the wharfage charges to a point which will yield only enough revenue to pay for the maintenance of the water front and to pay the interest on the investment in improvements. Where the wharves are privately owned, the maximum wharfage rates are sometimes prescribed by law or municipal ordinance in order to prevent extortion; but the lowest charges, considering the facilities furnished, seem to be found, as a rule, where the wharves are publicly owned. Thus at San Francisco the wharfage charges are unusually low, being only 5 cents per ton for grain and general merchandise, which at some other ports pay 25 cents and even 50 cents per ton. At Seattle a comparison of the charges at the municipal and other wharves shows similar contrasts; thus the rate for lumber is 15 cents per M at the municipal wharf, as compared with 50 cents to $1 per M at other wharves.

The importance of wharfage charges is indicated by the statement of the traffic manager of the Pittsburg Chamber of Commerce, to the effect that excessive charges along the Ohio River offset the lower rates of water transportation as compared with rail transportation, and in the case of small towns cause the steamboats to pass by without landing at all, depriving these places of the benefit of water competition.

COMPULSORY PILOTAGE.

The employment of a pilot and payment of pilotage by vessels entering a seaport has commonly been made compulsory by state laws, in order to insure the presence of a sufficient number of skilled pilots to serve all vessels; but vessels engaged in the coasting trade only are now commonly exempted from the requirement of compulsory pilotage. In several of the South Atlantic States, however, sailing vessels in the coasting trade are still required to pay pilotage fees.

A large proportion of the sailing interests reporting to the Bureau of Corporations from the Atlantic coast complain of compulsory pilotage as an unjust discrimination against sailing vessels. Before entering the harbors and navigating the rivers of the several States south of Virginia on the Atlantic coast, sailing vessels are required by state laws to employ local pilots, or to pay the prescribed pilotage fee to the first pilot offering his services, whether he is actually employed or not. Formerly steamers were also subject to this requirement; but the difficulties of navigation which originally justified compulsory pilotage having been gradually removed by river and harbor improvements, steam vessels engaged in the coasting trade were freed from the requirement by act of Congress in 1871. Bills have repeatedly been introduced in Congress for the relief of sailing vessels from this burden, but they have failed of enactment.

Sailing interests maintain that sailing vessels can be as safely navigated on the waters of Southern harbors as can steam vessels.

Coasting vessels were exempted from compulsory pilotage in Virginia waters by the state legislature of 1908.

PART IV.—RAIL RATES AND WATER RATES, INCLUDING THEIR RECIPROCAL INFLUENCES.

GENERAL CONSIDERATIONS.

Water rates are usually more competitive than rail rates, mainly for the reason that water transportation requires practically no outlay for right of way and much less outlay for terminals than in the case of railroads. Operating costs of water lines therefore constitute a much larger proportion of the entire cost of transportation, and fixed charges are much lower.

Railroads have developed far more fully than water lines the system of freight classifications, there being at present three general rail freight classifications in the country, the Official, Western, and Southern. Some water lines operating jointly with rail lines have, however, adopted these classifications, or modifications of them. Traffic associations for the making of joint rates are much more common with railroads than with waterways. Unlike interstate rail rates, interstate water rates per se need not be filed or made public.

LONG-DISTANCE TRAFFIC.

The most striking characteristic of the American railroad rate system has been the extreme development of the long-distance traffic by means of relatively low rates. It is true that in many instances a tariff is used, somewhat approaching a "distance tariff," with rates proportioned roughly to the length of the haul, but the exceptions to the distance tariff principle are extremely common, and in fact the general tendency has been toward another principle, that of a wholesale rate. Railroads have given low rates for large long-distance traffic between important markets. There has been an extreme effort on their part to equalize different producing districts in the same market, regardless of differences in distance, and thus to make, to a certain extent, the producers of a given commodity all over the country competitors in all markets. This has resulted in a system of long-distance traffic and long haul peculiar to the United States.

This has had a marked effect on the waterway system. The business of the country has thus been adjusted to long-distance transportation, while our waterway system is mainly an aggregation of separate units of widely differing physical characteristics. It is therefore far less adapted for continuous through traffic that are the railroads. It is thus unable to meet the demands of modern business as developed by the railroad. In comparing, therefore, European water systems with our own waterways this difference must be borne in mind and we must recognize the peculiar demand which is made in this country upon our entire transportation system, including the waterways, and the peculiar difficulty which our waterways here have therefore to meet.

PRORATING.

The above considerations involve the question of the prorating between railroads and waterways. The railroads have exercised a marked effect over waterways by refusal to prorate with them in many cases, and especially with rivers and canals, although prorating is practically the rule among railroads. To give an example of prorating, a railroad, for instance, from New York to Chicago will join with a railroad from Chicago to San Francisco in making a through rate from coast to coast which is lower than would be the sum of the two local rates New York to Chicago and Chicago to San Francisco. This is called prorating. It is simply the making of the two roads one for the purposes of the agreement and applying to that joint route the well-known long-distance principle of a relatively lower charge for a longer distance. But in the case of rivers the railroads very rarely make any such lower through rates. The shipper in such cases sending his freight partly by rail and partly by water must pay the full rail rate to the water terminus, and then the full water rate to destination; that is to say, the sum of the two local rates. The railroad does not join with the waterway in making a through rate less than this sum and dividing this low rate between them. This, of course, tends to make the rates for an all-rail haul relatively lower than for the same distance by rail and water, because it applies to the all-rail haul the long-distance principle, while the rail-and-water rate covering the same entire distance is governed by the principle of short-distance shipments, which always take a higher rate per ton per mile.

Now, inasmuch as all shipments of importance for any considerable distance must go at least in part by rail, it is obvious that this power of the railroads to refuse to prorate with the water carrier is a very effective weapon in preventing shipments by water. Such failure to prorate is especially frequent and especially effective on the waterways of the Mississippi Valley. So far as present information goes, there are no such rail-and-water prorating arrangements in effect on the Mississippi below St. Louis, except at certain points on the Black River and to certain points in Louisiana not reached by rail. When prorating does appear as between rail and river lines, it is usually to points of minor importance or where without such rail-and-water arrangement the railroad could do no business at all.

It is true that in some cases the water lines have themselves preferred not to prorate with railroads, lest the water lines should by such "joint arrangement" make themselves subject to the special provisions of the interstate commerce act.

This power over prorating is also frequently used by the railroads in another way—that is to say, not to prevent shipments by water, but to send rail-and-water shipments over a certain favored water line, usually affiliated with or controlled by the railroad. It does this by exclusively prorating with that line.

That is to say, in brief, the railroads of the country, by refusal to prorate, can, and in large measure do, prevent the rivers and canals from becoming a part of the whole transportation system of the United States, or else they thus extend their control over the waterway system by prorating only with favored affiliated water lines. It follows, necessarily, that the water line thus favored will, other things being equal, overcome water lines not so favored.

COMPARISONS OF RAIL AND WATER RATES—ATLANTIC AND GULF COASTS.

Coastwise all-water rates on coal are much lower than rail rates as between coast points. To interior points, however, the railroads compete with the water routes. The same is true of lumber. Water rates on cotton between coast points are much below the rail rates. The all-water rate from Galveston to Boston in 1907 was 40 cents, while the all-rail rate was 97 cents. It should be noted, however, that local water routes along the coast and its tributary rivers do not show rates much lower than rail, thus differing from the long-distance movement.

CANAL RATES.

Any comparison here is extremely difficult by reason of the confusing variety of tolls, lockage and towage charges, and also the difference in service. In general, canal rates show little advantage over rail rates. The inland route, however, between Philadelphia and Albemarle Sound by way of the Chesapeake and Delaware and other connecting canals has rates on coal and lumber considerably less than the all-rail rates.

GREAT LAKES.

In the through bulk movement of iron ore and coal between the upper lakes and Lake Erie, the advantage of the lake routes is so decisive that there is practically no rail competition. In the grain movement from Lake Michigan there has been active competition, and the rail rate varies accordingly, dropping in the summer during the season of navigation, and rising in the winter.

Water rates on lumber between lake points are lower than all-rail rates. The water rate Duluth to Chicago, 1907, was $2.50 per thousand feet; all-rail rate, about $4. But, again, as soon as interior points are considered, the advantage of the lake route declines. On through package freight the class rates by lake and rail and by canal and lake are regularly lower than the all-rail rates. From New York to Chicago the standard all-rail rate on class 1 is 75 cents; joint rail-and-lake rate, 62 cents; canal-and-lake rate, 42 cents. The differentials, however, are much less to interior points beyond the lake terminals.

MISSISSIPPI VALLEY.

The notable decline in traffic on the rivers of the Mississippi Valley, except that in lumber and coal, indicates clearly that the freight rates of the regular river lines, in connection with other expenses, offer little or no advantage to the shipper over railway rates. The coal traffic is perhaps the exception that proves the rule; and, as pointed out in a previous part of this discussion, it is of a unique character. The cost of transportation by river on coal from Pittsburg to Cincinnati is about 74 cents a ton, while the rail rate is $1.35; but this traffic is almost entirely confined to points along the river, because the railroads make such high local rates for river coal when shipped back from the river.

Similarly, logs and lumber are exceptional, because very little equipment is required to move them. An exact statement of the cost of raft transportation is impossible. One sawmill company estimates that it costs about 50 cents per thousand feet to float logs down the rivers in West Virginia, make up rafts, and tow the rafts to Cincinnati. The corresponding railroad rate is about $4.50 per thousand feet.

Class rates on freight moving between river points on the Ohio and Mississippi rivers and tributaries are usually less than the rail rates on the same traffic. Against these lower rates, however, must be considered the cost of marine insurance and terminal charges. The net result in most cases does not allow much differential in favor of the river. The river rates between St. Louis and Keokuk are about 20 per cent less than the all-rail rates. On cotton from river points below Memphis to that city the rail rate has been $1.25 per bale, river rate 75 cents, but to the river rate must be added 20 cents a bale for insurance and 25 cents for drayage in Memphis, and often the cost of a longer haul to the point of original shipment.

PACIFIC COAST.

There is here a large coastwise movement of lumber with little rail competition. The rates fluctuate more or less. On traffic generally the influence of ocean competition is shown in the relatively lower rail rates between coast points than to inland points in the same territory. Rail rates from San Francisco to Ashland, Oreg. (an interior point), are twice to three times as much as are the rail rates to Portland, a much greater distance.

On local bay and river routes the railroads operate or control boat lines competing actively with independent boat lines. Rail rates to competitive points are thus in most cases reduced to the level of water rates, while to nonwater points at corresponding distances rail rates are much higher. These conditions appear on the rivers tributary to San Francisco Bay and on Columbia River and Puget Sound. Both rail and water rates along the Columbia River were reduced after the opening of the canal around the Cascades in 1895.

TRANSCONTINENTAL RATES.

The effect of water competition on transcontinental freight rates is quite marked. In general, class rates from New York to the Pacific coast via the Panama route are from 20 to 42 per cent lower than the all-rail rates. Rail rates to intermediate points slightly east of the Pacific coast are frequently determined by the rates to the coast plus the local rate back from the coast, these being among the marked exceptions to the principle of the long and short haul clause.

COMPETITIVE METHODS OF RAILROADS.

The power of granting or refusing prorating arrangements has already been noted as a most effective means of competition. Railroad control of strategic terminal facilities, and especially transfer points, is also an important factor.

Where water lines are weak, railroads have frequently engaged in destructive competition, making rates to competitive points along the waterway lower than rates covering similar distances inland. This has involved a number of interpretations of the so-called long and short haul clause of the interstate commerce act. This clause substantially prohibits the charging of "a greater compensation * * * for the transportation * * * under substantially similar circumstances and conditions for a shorter than for a longer distance over the same line in the same direction, the shorter being included within the longer distance." The words "substantially similar circumstances," however, have been so broadly construed as to take away largely the effect of the section. The United States Supreme Court, on a review of the decision of the Interstate Commerce Commission in the Alabama Midland case (168 U. S. 144; 1897), cited the possibility of potential water competition in connection with the competition of other railroads and trade centers, as a factor in establishing circumstances that were not "substantially similar," and to be lawfully considered in making railroad rates.

The result has been that the railroads have continued to reduce rates at many points where water competition occurs, while they may recoup themselves at inland points and thus, at no net loss to themselves, greatly injure the water-borne traffic. This is shown by a comparison of the railroad rates from points along the Mississippi to New Orleans with the rates from points inland at the same distance from New Orleans, the inland rates being in almost all cases much higher. Rail rates from New Orleans to Bayou Sara, on the river, average about 16 cents per hundred pounds less than to Hattiesburg, a shorter distance; to Greenville the rates average about 16 cents less than to Rolling Fork, Miss., a shorter distance; to Memphis the rates average about 17 cents lower than to Mount Vernon, which is less than half the distance.

Certain broad results of rail and water competition are illustrated in the following specific instances:

(*a*) That of the so-called Southeastern Differential Territory, a wide strip on the South Atlantic coast reaching inland several hundred miles. There is a strong waterway traffic from the North to the South Atlantic coast. Accordingly in this case the railroads have conceded this "differential territory," in a way, to the water lines. That is to say, there exists a general arrangement of long standing that the rates, for instance, from New York to Charleston by water, plus the rates by rail from Charleston inland, within the limits of this territory, shall be less than the all-rail rate from New York to the point of final destination. This differential in favor of the waterways, of course, tends to give them traffic within this territory.

This is evidently a case where there is strong water competition, and the railroads have been obliged to concede a share of the traffic to it. In this case also, however, the railroads have used another method, namely, that of absorbing the chief water lines. Most of the important coastwise lines running down the South Atlantic coast are controlled by or closely affiliated with important railway systems.

(*b*) The Great Lakes. This is another case of strong water competition. Here the railroads have used the latter method, namely, that of absorption or control, many of the important packet lines on the Lakes being owned or controlled by the trunk line railroads.

(*c*) The Pacific coast. Here the railroads have again used the latter method. Most of the important steamer lines, both ocean and local, are controlled by railroads.

(*d*) The Mississippi Valley. This is a case of a comparatively weak waterway, and its competition has been met by destructive competition on the part of the railroads, by the lowering of rates to competitive water points and the taking away of most of the former river traffic, so that it is now in a condition of extreme decline. The railroads have also in many cases succeeded in shutting in the Mississippi traffic—as, for instance, the coal business—practically to the banks of the river.

EFFECT OF WATERWAYS ON RAILROADS.

It is a curious fact that the ordinary inland waterway seems to be more potential in causing the reduction of railroad rates than in securing traffic for itself, though there is a marked difference between waterways in this respect, and any consideration of them must keep in mind these variations, and great care be taken in deducing general conclusions from the conditions of one class of water routes.

Rates on cotton from interior shipping points show the influence of water competition in lower rail rates from river points such as Vicksburg and Augusta, as compared with nonriver points such as Jackson, Miss., and Atlanta. The rail rate from Charleston to Jacksonville is lower than from Savannah to Augusta, though the latter distance is only one-half the former. The lake rate Chicago to Sheboygan on class 1 is 27 cents and the rail rate 30, while to interior points at similar distances the rail rates are higher—to Fond du Lac 40 cents and to Oshkosh 43 cents.

Innumerable instances might be cited of the effect of water routes on rail rates. The foregoing are merely examples of a large class.

SCOPE OF THE EFFECTS OF WATERWAY COMPETITION.

It is an important fact that the effect of water competition on rail rates is much broader than would at first be expected, by reason of certain outside circumstances. These are the effect of competing markets, competing railroads, and the interdependence of railroad rates generally. An example may be stated as follows: Suppose that there is a rail rate from St. Louis to New Orleans on a given commodity of 40 cents a hundred pounds. Suppose also a similar rate exists on the same commodity from Chicago to New Orleans. Suppose, now, river competition between St. Louis and New Orleans arises suddenly and the St. Louis-New Orleans railroad is obliged to reduce its rate to New Orleans to 30 cents to meet this new river competition. Immediately the other railroad running between Chicago and New Orleans is met with a demand by its Chicago shippers that its rate also be reduced to 30 cents to New Orleans, in order to put Chicago producers of that commodity on a par with St. Louis producers in the New Orleans market. The Chicago-New Orleans road, therefore, having no interest in St. Louis, but being interested in the traffic from Chicago, is under strong inducement to make a similar reduction to 30 cents. Furthermore, if this be done the other connections of the Chicago-New Orleans road will be affected by the change, as will also its immediate competitors from other markets competing with New Orleans. Finally, the numerou rate agreements, which often involve adjustments of rates over extensive areas, will also be affected by this change, so that the entir effect of the original river competition may thus be very greatly broadened.

CONCLUSIONS.

It will thus be seen that any consideration of the waterway question must first take account of its relations with the rail system The two are inevitably part of a general transportation system. S long as the two are run in opposition the waterways will inevitably suffer by reason of their lack of adaptation to modern transportatio demands. It is almost axiomatic that our waterways can not carr their reasonable proportion of the country's traffic, nor can their business ever be equal to their reasonable possibilities unless th present destructive competition with the rail system can in some wa be modified and the two systems be made to cooperate.

GROWTH OF INTERNAL AND FOREIGN COMMERCE.

By O. P. Austin,

Chief of the Bureau of Statistics, Department of Commerce and Labor.

Conservation and commerce are so closely allied and the latter, commerce, so much affected by the application of the former, conservation, that a very few words on commerce may not be inappropriate to this discussion of conservation. This seems particularly true in case the discussion should relate especially to internal commerce, or the exchanges of our own people among themselves. True, the foreign commerce of the United States has grown from $300,000,000 in 1850 to $3,000,000,000 in the fiscal year 1908, being to-day practically ten times as much as in 1850; while population meantime was growing from 23,000,000 to 86,000,000, the per capita foreign commerce thus being $13.71 in 1850 and in the fiscal year 1908, $34.74, an increase of about 150 per cent in the per capita value of our foreign commerce. In internal commerce, however, which seems more closely related to the question of conservation, perhaps because of its greater importance than the foreign commerce and of its closer relation to the people in their every-day life—in internal commerce the growth has been much greater, the internal commerce of the United States having been valued at $2,000,000,000 in 1850 and over $28,000,000,000 in 1907, being thus practically fourteen times as much in 1907 as in 1850; while the per capita value of the internal commerce, which in 1850 was $86, was in 1907, $315. Thus, while foreign commerce is to-day ten times as much as in 1850, internal commerce is fourteen times as much as at that period; and the per capita of the foreign commerce is now practically three times as great as in 1850, while the per capita value of the internal commerce is now practically four times as much as in 1850. The internal commerce of the United States, including in this term merely a single transaction in all the merchandise forming the exchanges among our own people, was in 1850 practically seven times as great as the entire foreign commerce, and in 1907 was nine times as great as the entire foreign commerce, and equaled in value all of the imports plus all of the exports of every nation of the world.

The measurement of the internal commerce of the United States is arrived at by a process entirely different from that by which the foreign commerce is measured. In determining the value of the foreign commerce, we require from every importer and every exporter a statement of the true value of the merchandise which he is importing or exporting, and aggregating these imports of all ports and exports of all ports we get the grand total of our foreign trade, which in the fiscal year 1908 aggregated, as already indicated, $3,000,000,000, against a little more than $300,000,000 in 1850. To measure the internal commerce of the country is more difficult, however, since there are no gateways through which it passes and at which a statement of its value may be required. It is possible, however, by a different process to determine the value of the merchandise which passes from hand to hand for consumption within the United States; and as statements of foreign commerce include merely the value of the articles comprising it, the measurement of the internal commerce by a statement of the value of the articles which it includes, and thus of a single transaction in those articles, seems to be a logical and fair one, We may, therefore, assume that if we can determine the value of the articles which form the internal commerce the measurement may at least approximate in accuracy the measurement of the foreign commerce to which we are more accustomed.

Fortunately, we are able to determine at certain dates in our national history the value of at least the principal articles entering the internal commerce of the country. The census shows the value of manufactures, of agricultural products, the products of the mines, the fisheries; and the record of imports shows the value of merchandise brought in from foreign countries and subsequently entering the internal commerce. By aggregating these stated values at the place of production of the principal articles entering the internal commerce of the country and adding a reasonable sum as the probable cost of transporting them to the consumer, we may at least approximate the value of the merchandise consumed among our own people, a single transaction in which may be properly accepted as a measurement of the value of the internal commerce. The census of 1900 showed the value of manufactures in the United States to be $13,000,000,000; of products of agriculture, practically $4,000,000,000; and of minerals, about $1,000,000,000. The importations of 1900 were practically $1,000,000,000 in value. Adding to these the products of the forests and fisheries and the increased value of all products due to transportation from the place of production to the purchaser, we may fairly set down the value of the internal commerce of the country as measured by a single transaction in those articles at $20,000,000,000 in the year 1900.

Applying this method to earlier and more recent years, I find that the value of the internal commerce of the country may be reasonably estimated at $2,000,000,000 in 1850, $3,500,000,000 in 1860, $5,000,000,000 in 1870 (gold value), $7,750,000,000 in 1880, $12,000,000,000 in 1890, $20,000,000,000 in 1900, and $28,000,000,000 in 1907, the last named year being estimated upon the census figures of manufactures for 1905, the Agricultural Department's estimate of the value of farm products in 1907, the Geological Survey estimate of the value of mineral products, and the stated value of imports of that year. Comparing these with the census figures of population, we get the per capita value of the internal commerce in 1850, $86; in 1860, $111; in 1870, $132; in 1880, $154; in 1890, $192; in 1900, $261; and in 1907, $326. Meantime the per capita wealth has grown, according to the census figures, from $307 in 1850 to $514 in 1860; $780 in 1870; $850 in 1880; $1,039 in 1890; $1,165 in 1900; and $1,310 in 1904, the latest year for which estimates have been made, the increase in per capita wealth having been slightly greater than the increase in per capita of internal commerce.

$\frac{300}{9000}$ $\frac{3}{28000}$ [illegible]

IRRIGATION.

By F. H. Newell,
Director United States Reclamation Service.

The National Government has passed three important laws for the encouragement of irrigation; (*a*) The desert land law, which was best adapted to individual enterprise in the development of comparatively small tracts of land by irrigation systems of moderate size; (*b*) The Carey act, which was designed to encourage corporate irrigation of public land under state auspices; (*c*) the reclamation act, which provides for construction of irrigation works by the National Government itself. Enumeration was made by the United States census of the acreage irrigated in 1889, 1899, and 1902. With those figures as a guide, and by the use of the general information possessed by the Reclamation Service, an estimate has been made of the acreage irrigated in 1907. The results given in the following table include very large areas which receive only one or two irrigations by flood water, and others where the supply is inadequate.

Irrigation in the United States.

NUMBER OF FARMS IRRIGATED.

Year.	United States.	Arid region.	Semiarid region.	Rice region.
1907	[a] 167,200	152,000	7,800	7,400
1902	133,356	122,156	7,021	4,179
1899	110,117	102,819	4,897	2,401
1889	54,136	52,584	1,552	....

[a] Estimated.

NUMBER OF ACRES IRRIGATED.

1907	[a] 11,000,000	9,700,000	425,000	876,000
1902	9,681,280	8,471,641	405,440	600,199
1899	7,778,904	7,963,273	266,417	251,214
1889	3,631,381	3,564,416	66,965	....

[a] Estimated.

Irrigation by individual effort has been undertaken in each instance in a small way, but in the aggregate this method has led to the most important development and has resulted in the largest total acreage. It is also being developed to some extent by corporate enterprise, but results from this source are relatively meager, except where the corporations are of a community character. Cooperative communities have done much in the past and their future works will probably be important. Development by States under the provisions of the "Carey Act" promises well in some localities where there is efficient state supervision, as in Idaho, Wyoming, and Oregon; large results have already been accomplished in the first-named State. National development through the agency of the Reclamation Act is beginning to show results and is steadily proceeding. It has been confined mainly to those enterprises which are too large, too costly, or too slow in producing returns to tempt private or corporate investments.

The Reclamation Service has 29 projects in various stages of construction; these contemplate the ultimate irrigation of 2,700,000 acres, against a total acreage of 367,023 for which water was furnished in 1908. The following table shows the distribution of the projects, the total ultimate irrigable area under each, and the irrigated areas for 1908 and 1909:

Irrigation projects.

State.	Project.	Irrigable area.	Irrigated 1908.
		Acres.	*Acres.*
Arizona	Salt River	272,000	115,000
California	Orland	14,000	.....
California-Arizona	Yuma	92,000	3,800
Colorado	Grand Valley	62,000	.....
	Uncompahgre	147,000	15,600
Idaho	Minidoka	74,000	24,464
	Payette-Boise	315,000	55,000
Kansas	Garden City	8,500	5,558
Montana	Huntley	28,000	4,400
	St. Mary	.....	.....
	Sun River	256,000	.....
Nebraska-Wyoming	North Platte	164,000	23,220
Nevada	Truckee-Carson	200,000	27,450
New Mexico	Carlsbad	20,000	8,000
	Hondo	10,000	1,500
	Rio Grande	180,000	17,000
North Dakota	Buford-Trenton	12,500	1,200
	Williston	12,000	2,000
North Dakota-Montana	Yellowstone	66,000	.....
Oklahoma	Cimarron	.....	.....
Oregon	Umatilla	20,000	2,500
Oregon-California	Klamath	187,000	9,378
South Dakota	Belle Fourche	100,000	5,000
Utah	Strawberry	60,000	.....
Washington	Okanogan	10,000	1,353
	Sunnyside	90,000	42,000
	Tieton	30,000	.....
	Wapato	120,000	.....
Wyoming	Shoshone	150,000	2,600
		2,700,000	367,023

Under the Carey Act there have been approved 1,716,424 acres for construction, and patents have been granted covering 293,083 acres.

The following table shows the location of the lands being irrigated under this act:

Segregations applied for under the act of August 18, 1894 (28 Stat. L., 372–422), and the acts amendatory thereof, with the action taken thereon, from the passage of the act to July 1, 1908.

[Areas in acres.]

State.	Selected.	Rejected, relinquished, etc.	Approved, not patented.	Approved and patented.
Colorado	59,807.94	5,704.95	54,102.99	.....
Idaho	1,180,566.17	265,828.94	662,254.00	156,954.90
Montana	104,587.98	2,792.53	83,498.54	18,296.91
Nevada	12,644.61	8,000.00	.....	.....
Oregon	432,202.53	78,507.31	245,287.52	50,063.13
Utah	328,327.40	236,980.83	48,226.74	.....
Washington	155,649.39	155,649.39	.....	.....
Wyoming	965,508.64	198,994.18	623,054.44	67,768.72
Total	3,239,384.66	952,458.13	1,716,424.23	293,083.66

Oregon segregation list No. 5, covering 58,344.57 acres, is now pending before the Secretary on appeal from the decision of the General Land Office rejecting it.

Wyoming segregation list No. 27, covering 26,936.03 acres, was rejected by the General Land Office, which decision was affirmed by the department, but said decision has not yet become final.

Irrigation under the Indian Service is rapidly increasing.

The extent to which the irrigated area in the arid and semiarid regions can be increased can not be accurately estimated with present knowledge. If all the run-off waters of the arid region could be conserved and employed in irrigation, the total area might, perhaps, be brought to nearly 60,000,000 acres. This is very uncertain, however, as our knowledge of run-off is confined to only a portion of the streams, and is incomplete; furthermore, such an estimate involves assumptions regarding the duty of water that may introduce large errors.

It is known, however, that large portions of the water of the arid region can not be used in irrigation, as no irrigable land exists upon which it can be brought at feasible cost. In general, it may be stated that the value of irrigated land is increasing, and certain developments are tending to decrease costs of construction, so that it is impossible to draw any approximate line of demarkation, even if we had full knowledge regarding present costs. This would require elaborate surveys, which have not been made. For these reasons any present estimate of the total irrigable area would necessarily be little better than a guess. With present data, the closest statement is probably between 40,000,000 and 50,000,000 acres, including that now under ditch.

The subjects of irrigation, forestry, navigation, power, domestic water supply, and drainage are all closely interrelated and should be thoroughly studied together, not only in the arid but in the humid regions. No one of these questions can be properly treated without full regard to all the others. Proper study of these comprehensive questions should include more extended observations of rainfall and evaporation, especially in high altitudes, and of the annual flow of all streams. Comprehensive topographic maps should be made showing the areas of drainage basins, the location of reservoir sites, and their relation in altitude and location to irrigable lands and to power and navigation resources. Such maps are the basic information most urgently needed for all land classification, and without them no wise policy can be adopted.

Water laws.

Both state and national laws are incomplete in permitting and encouraging the settlement and improvement of lands which should be reserved for reservoir sites. Thorough surveys should be made and all feasible reservoir sites discovered and reserved for development.

The present laws in some States tend to promote irrigation, but in others they do not. The most primitive form of regulation of the use of water in irrigation is best exemplified by the present laws of the State of California. These declare the principles of priority and beneficial use, and provide that claims to the use of water shall be recorded in the form of a notice of appropriation, and shall be perfected by application to a beneficial use. At the same time they try to recognize as concurrent on the same stream rights derived by prior appropriation and rights depending on riparian ownership. The riparian doctrine of water rights should be definitely and permanently abrogated in all arid regions. This has been done in some States by constitutional provision and in some by judicial decision. In all the States of the arid region where the riparian doctrine is recognized, material modifications in the old common-law doctrine have been made and put into effect.

The form and theory of these laws have been developed by several of the States, elaborating upon the principles of the California laws and the methods established in that State.

The operation of the earlier forms of these laws places no restraint upon appropriations of water. The courts in passing upon the claims of the appropriators, having scant information concerning the amount of water available for use, with no guide to the quantities which should be applied in the cultivation of crops, and confronted with the excessive claims of the parties, have often adjudicated rights to the use of water many times in excess of the amount carried by the stream.

The knowledge obtained during recent years concerning the discharge of streams and the use of water has caused such decrees to become exceptional in present practice. Nevertheless, the need for a more careful regulation of the appropriation and use of water has been apparent for many years.

In 1890 the State of Wyoming enacted a code of water laws providing for supervision of the utilization of the water supply through a state engineer and state board of control who adjudicate rights to the use of water in the first instance. The division superintendents and water masters have immediate charge of the distribution of the water in the various water divisions.

Nebraska subsequently adopted a code of water laws similar to the laws of Wyoming.

Idaho, Utah, and Nevada in 1903 adopted codes of water laws based upon those of Wyoming with, however, a number of important modifications dictated by experience and the development of irrigation practice.

At the sessions of the legislatures of Oregon and Washington in 1903, the governors were directed to appoint commissions to prepare and submit drafts of a code of irrigation law.

At a joint session of the two commissions with the then chief engineer and other members of the Reclamation Service held in August, 1904, the fundamental principles of a modern irrigation code were discussed. There was also some consideration of the provisions which should be incorporated in such a code to facilitate the operations of the Federal Government in carrying on the work of constructing the irrigation systems contemplated by the act of Congress approved June 17, 1902 (32 Stat., 388), known as the Reclamation Act.

After this meeting, a state code of water laws was drafted by Mr. Morris Bien, supervising engineer of the United States Reclamation Service, which, in 1905, was adopted without material change by the legislatures of North Dakota, South Dakota, and Oklahoma. The legislatures of Oregon, Washington, and New Mexico adopted parts of this code, but omitted some of the most important features. This code does not involve any new principles, but constitutes a revision and combination of the features of the more modern statutes, arranged as a consistent and complete code.

Proposed water code.

A state code of water laws should provide for the appropriation, adjudication, and apportionment of the waters of the State, and divides itself naturally into four branches.

First. A declaration of the fundamental principles upon which the right to use water shall be based.

Second. The adjudication of rights to the use of water claimed under the previous laws, thus determining the unappropriated public waters.

Third. The regulation, control, and determination of the rights to water to be subsequently acquired.

Fourth. The regulation and control of the distribution of water, rights to the use of which have been established.

The code under discussion is arranged to provide appropriate procedure for the application of these principles.

Under the first heading the fundamental principles are few and well established, namely, that all the waters within the limits of the State belong to the public and are subject to appropriation for beneficial use, except from sources of supply which are navigable; that the prior appropriation of water shall be the basis, and beneficial use the measure and the limit of the right; that the use of water is a public use, and private parties may exercise the right of eminent domain for the utilization thereof; and that water used for irrigation shall be appurtenant to the land on which it is used.

Under the second heading, providing for the adjudication of rights claimed under prior laws, it is now generally conceded that the final adjudication must be by the courts. The codes of the different States contemplate various forms of procedure. In the code referred to, a state engineer, appointed for six years by the governor subject to confirmation by the Senate, is to make a complete hydrographic survey of a stream system, obtaining all the data necessary to determine the amount of water available and the rights of the parties entitled to the use of it. This material is turned over to the attorney-general of the State, who is required to enter suit promptly for the determination of the rights of all parties and to prosecute the same diligently to a conclusion. In all suits for the determination of the right to the use of the waters of any stream system, all who claim the right to use such waters shall be made parties. In all suits involving the determination of water rights, the attorney-general is required to intervene on behalf of the State, if in the opinion of the state engineer the public interest requires it.

The third subject, namely, that of the regulation, control, and determination of rights to the use of water to be acquired, is placed in the hands of the state engineer. The procedure proposed is substantially the same as that adopted in the other States having a modern irrigation code with some differences of detail.

The principal feature to be noticed is that before any work looking to the construction of an irrigable system is commenced, and after the state engineer has passed upon the form and substance of the application, the intention to appropriate the water shall be published in a newspaper circulated in the community. After such publication the state engineer will approve the application if no valid objection is presented.

When the construction is completed, the works are to be inspected and approved by the state engineer, who will then determine their capacity, which will limit the amount of the appropriation. Afterwards when the water is applied to a beneficial use, the state engineer makes a further inspection, whereupon he issues a license for the appropriation of the amount of water which has been applied to a beneficial use. A time limit is fixed for completion of construction and for beneficial use.

For the distribution of the water, which comes under the fourth branch, the States are divided by the law into water divisions by drainage areas, each under the supervision of a water commissioner appointed by the supreme court of the State. Their function being the distribution of water under judicial decree or appropriation, they may be regarded as, in a sense, officers of the court. The water commissioners with the state engineer constitute a board of water commissioners, of which the latter is president. The water commissioners each serve six years, their terms being so arranged that a new one is appointed every two years. This board has general supervision over the waters of the State.

The actual work of distributing the waters to those entitled to use them is performed by water masters appointed by the water commissioners with the approval of the state engineer. Each water master has charge of a water district set apart by the state engineer, as found necessary from time to time. The operations of the water master are under the supervision of the water commissioner, and their acts are subject to appeal to the state engineer.

The cost of the water distribution is borne by the water users. The general expenses of the state engineer and the water commissioners are paid by the State. The greater part, if not all, of this expense will be returned to the state treasury by the fees collected by the state engineer and by the repayment of the cost of hydrographic surveys by the parties to the suits for adjudication.

Special reference should also be made to the features of the draft relating to the work under the federal Reclamation Act.

In order that the State may obtain the full benefit of this work and to prevent serious interference with, and perhaps the entire abandonment of, the projects which are considered for investigation, it is provided that the water supply for such projects shall be reserved from general appropriation until the investigations of the Reclamation Service shall determine the precise amount required for the project, the remainder being then released from such reservation.

It is also provided that state lands coming under such project shall be disposed of in harmony with the plans for the disposition of the lands of the United States, and that lands required for the reclamation project for irrigation works shall be transferred to the United States without charge.

In all sales of state lands after the enactment of the code, the conveyance is to reserve right of way for ditches or canals constructed by authority of the United States.

The theory of these provisions is that the State regulates the appropriation of the water, exercising this power and holding the land in trust for the public, and when the interests of the public are so directly involved as in these large irrigation projects, and when, further, there is no element of individual speculation or profit in the construction of the works, which are for the purpose of establishing the maximum number of homes on the land, it is the duty of every State to which the Reclamation Act is applicable to assist with every resource under its control.

It will be of interest to review several of the other provisions of the draft.

Units of measurement are established; the cubic foot per second for the flow of water and the acre-foot for volume. The miner's inch is fixed as one-fiftieth of a cubic foot per second, unless a different ratio has been agreed upon by contract or established by actual measurement or use. The miner's inch has been used in some States as a unit, but it is unsatisfactory, because it is not easily defined with exactness.

The amount of water which may be appropriated for irrigation is limited to 1 cubic foot per second for 70 acres or its equivalent.

While it is conceded that water used for irrigation must be appurtenant to the land, the fact should be recognized that conditions may arise to make it impracticable or uneconomical to continue to irrigate a particular tract. Provision is made so that the use of water may be severed from the land after application to the state engineer, due publication of notice of such intention, and approval by the state engineer. Similar provision is made for a change in the nature of the use to which the water is applied, or in the place of diversion, storage, or use.

The subject of seepage water is one that has given much trouble, and provision is made for the appropriation thereof in the same manner as other waters, with the requirement that the appropriator must pay reasonable charges for storage or carriage to the owners of the irrigation works from which it comes, provided that the seepage can be traced to such works beyond reasonable doubt.

All decisions of the state engineer or water commissioners affecting a substantial right are subject to appeal to the courts.

Adoption of code.

In the session of 1907 the Montana legislature considered a draft of a code prepared by a commission appointed by the governor which followed substantially the code referred to, but it was not adopted. The same is true with the legislature of Oregon.

During the year 1908 there has been a general movement toward the preparation of a code substantially in the form considered in the State of Oregon, and it is probable that it will be strongly urged upon the legislature early next year.

In many of the States statutes have been adopted tending toward the system discussed, and as this procedure is gradually enforced and modified as may be found advisable after experience, those States in which such laws have been enacted will do much toward the proper promotion of the irrigation industry.

It is generally conceded that those States in which statutes of this kind are not in force can best assist in the development of irrigation by following the principles and procedure there indicated.

One important feature of the law of irrigation has thus far received no attention in legislation, namely, the regulation of interstate waters. The decision of the United States Supreme Court in the Kansas-Colorado case (206 U. S., 46) and the decisions of some of the district courts of the United States in other cases, together with some decisions by state courts, have shown a tendency to consider this question, but in no case has there been an announcement of a principle which tends to meet the complicated conditions.

All the cases concerning interstate waters have involved only specific rights of the litigants; nothing has yet been accomplished outlining the method of providing for an adjudication of the waters of an interstate stream in such manner as to determine all the rights involved.

The principal difficulties arise from the fact that suit may be brought by one party against another and a decision obtained, which would not, however, bind anyone who is not party to the suit, and the complications in judicial procedure are such as to make it difficult, if not impracticable, under present conditions and rulings to bring into consideration in any one case all rights on interstate streams in two or more States and so arrange that one adjudication shall determine the rights of each party as against all other users of water from that stream.

Whether this matter can be adjusted by the courts themselves without the assistanc of legislation or whether legislation is absolutely necessary has not yet been demonstrated.

It has been proposed by some that Congress should provide for a tribunal empowered to investigate claims to the use of water of interstate streams and to prepare reports upon all facts affecting priorities and the use of water, the same to be submitted to the federal courts for adjudication, following in general the procedure outlined in the proposed code in regard to the adjustment of water rights within the State.

IRRIGATION.

By Dr. Samuel Fortier,

Chief of Irrigation Investigations, Office of Experiment Stations.

LAND NOW UNDER IRRIGATION IN THE UNITED STATES.

The following table gives estimates of the areas now irrigated in the arid States and Territories. For the States which have state engineers charged with the supervision of their water supplies, except Montana and Nevada, the estimates are made by the state engineers. Since these men are charged with the distribution of the waters of their respective States to the lands irrigated, their estimates are probably the best obtainable and very near the truth. For Arizona, Texas, Washington, and Nevada the estimates are made by men connected with the territorial and state agricultural colleges, whose duties have made them especially well-informed along this line. For California, Kansas, and Montana the estimates are made by representatives of the irrigation investigations of the United States Department of Agriculture, who have made studies of irrigation in those States, and can be considered the best authorities on conditions in them. The areas devoted to rice in Arkansas, Louisiana, and Texas are included in this table for convenience:

Areas irrigated in the United States.

State.	Area irrigated.	Authority.
	Acres.	
Arizona	200,000	R. H. Forbes, director Arizona Agricultural Experiment Station.
Arkansas (rice)	6,000	Yearbook, U. S. Department of Agriculture, 1907.
California	1,800,000	F. W. Roeding, U. S. Department of Agriculture.
Colorado	1,852,900	T. W. Jaycox, state engineer.
Idaho	2,665,000	Jas. Stephenson, state engineer.
Kansas	51,500	D. H. Bark, U. S. Department of Agriculture.
Louisiana (rice)	310,000	Yearbook, U. S. Department of Agriculture, 1907.
Montana	1,500,000	Samuel Fortier, U. S. Department of Agriculture.
Nebraska	250,000	
Nevada	500,000	G. H. True, University of Nevada.
New Mexico	400,000	V. L. Sullivan, territorial engineer.
North Dakota	[a] 64,300	T. R. Atkinson, state engineer.
Oregon	500,000	J. H. Lewis, state engineer.
South Dakota	42,000	S. H. Lea, state engineer.
Texas:		
General	500,000	J. C. Nagle, Texas Agricultural College.
Rice	284,000	Yearbook, U. S. Department of Agriculture, 1907.
Utah	830,000	W. W. McLaughlin, U. S. Department of Agriculture.
Washington	200,000	O. L. Waller, State College of Washington.
Wyoming	1,000,000	C. T. Johnston, state engineer.
	13,035,700	

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[a] Includes total under Reclamation Service ditches, 44,800 acres, much of which is not yet irrigated.

In addition to the areas given in the table there is a constantly increasing area being irrigated in the humid States. This is especially true of the trucking districts of the South Atlantic and Gulf States. However, no reliable estimates of these areas can be made. Census Bulletin 16 gives the area in 1902 as 5,788 acres, which is an increase of 76 per cent over the area reported in 1899. Assuming a like rate of increase since that time would make the present area about 14,000 acres.

HOW MUCH MORE LAND CAN BE IRRIGATED.

Prior to 1890 erroneous ideas prevailed regarding the extent of land which could be irrigated in the arid region. So little was then known of the water resources of this region and so large seemed the irrigable lands that the most conservative estimates were much too large. Fifteen or more years ago the most generally accepted estimate was 100,000,000 acres. As data on the flow of western streams were accumulated by the United States Geological Survey and as more irrigation enterprises were carried out, men began to have a more accurate conception of the limitations of the water supply and the difficulties to be overcome in utilizing even a small portion of certain streams. From 100,000,000 acres the estimate shrunk to 90,000,000 and then to 75,000,000. For a number of years it halted at 65,000,000 acres, but from reports received from the best authority in each of the sixteen arid States and Territories during the months of September and October, 1908, the total extent of land possible of irrigation is below 45,000,000 acres. It is reasonable to conclude that this estimate is likewise too large.

Areas irrigable in arid region of the United States.

State.	Area irrigable.	Authority.
	Acres.	
Arizona	1,000,000	R. H. Forbes, Director Arizona Agricultural Experiment Station.
California	10,000,000	F. W. Roeding, U. S. Department of Agriculture.
Colorado	2,893,900	T. W. Jaycox, state engineer.
Idaho	5,446,000	James Stephenson, state engineer.
Kansas	103,500	D. H. Bark, U. S. Department of Agriculture.
Montana	6,000,000	Samuel Fortier, U. S. Department of Agriculture.
Nebraska	1,000,000	
Nevada	1,500,000	G. H. True, University of Nevada.
New Mexico	2,000,000	V. L. Sullivan, territorial engineer.
North Dakota	1,540,000	T. R. Atkinson, state engineer.
Oregon	3,000,000	J. H. Lewis, state engineer.
South Dakota	191,900	S. H. Lea, state engineer.
Texas:		
General	800,000	J. C. Nagle, Texas Agricultural College.
Utah	2,000,000	
Washington	1,000,000	O. L. Waller, State College of Washington.
Wyoming	6,200,000	C. T. Johnston, state engineer.
Total	44,375,300	

The spirit of the West is characterized by its hopefulness, and state engineers and others are more or less influenced by this. Besides, state officers desire, as a rule, to make a good showing for their respective commonwealths, and the tendency is to exaggerate rather than to minimize the extent of the natural resources. This is particularly true of those pertaining to land and water.

Such men are apt to base their conclusions on the total available supply. Quite frequently they fail to consider whether it would pay to utilize all this supply. There are limited portions of the arid region so favored by climatic and soil conditions that crops to the value of several hundred dollars per acre can be annually grown. In such localities a large amount of money may be profitably expended in providing a water supply by means of deep wells or storage reservoirs. In the vicinity of Riverside, Cal., the annual cost of water to irrigate citrus orchards exceeds on an average $22 per acre. This price includes the annual charge for maintenance and operation as well as the interest on the value of a water right. When the cost is so high, the water may be pumped to considerable heights, and storage reservoirs may be built whose first cost exceeds $100 per acre-foot. Wherever such costly undertakings are successful, practically all of the so-called available water supply can be utilized.

On the other hand, in the colder portions of the arid region, where the crops grown are confined chiefly to grains and grasses, water for irrigation has a low value, and the time will never come when any agency, individual, corporate, or governmental, can afford to build irrigation structures of such magnitude and cost as will serve to utilize all of the available water. Since this limitation, arising from the amount of money which can profitably be expended on any project, calls for the most careful consideration in perhaps 95 per cent of the entire region west of the Missouri River, it follows that the value of water in irrigation is a controlling factor in determining the extent of land which can be irrigated.

A large part of the total available water supply of the arid and semiarid regions of the United States is already used each crop-growing season. In taking water from natural streams and other sources of supply, conducting it frequently long distances, and applying it to arid lands much is wasted. When all losses are deducted, the quantity of water which subserves a useful purpose in the growth of plants is small in comparison to the quantity diverted. Those best informed quite generally believe that two-thirds of the water which is now diverted subserves no beneficial purpose in nourishing plant life. In the prevention of at least a part of this waste is to be found one of the best means of conserving the water supply of the arid region.

According to the census of 1900, the area irrigated in the United States in 1899 was 7,539,545 acres, while the special irrigation census of 1902 gave 9,487,077 acres. Assuming the same rate of increase the area irrigated in 1908 would be over 14,000,000 acres. This estimate, although doubtless too large, is confirmed in a way by recent reports from western state and territorial engineers. These aggregate for the sixteen Western States and Territories over 13,000,000 acres. Now, when one considers the quantity and value of the water which is annually applied to so large an extent of land and the high percentage which might readily be saved by a more economical use, the figures are startling. A saving of even 10 per cent of the quantity now used and making it available for other lands would provide a supply for 1,400,000 acres, representing a value of about $50,000,000. A consideration of the extent of the losses herein briefly outlined would seem to indicate that fully 33⅓ per cent of the present supply might be saved by the prevention of a part of the waste. The water thus saved would provide a supply for an additional acreage of four and one-third million acres, and represent a value of over $150,000,000.

Seepage and evaporation losses from canals by groups.

[In cubic feet per second.]

Number of canals tested.	Capacity.	Miles of canal tested.	Total discharge.	Total loss.	Percentage of loss per mile.
17	100 cubic feet per second or over	359.63	5,319.51	1,037.84	0.92
20	50 to 100 cubic feet per second	270.97	1,458.65	341.36	1.73
20	25 to 50 cubic feet per second	114.68	714.21	142.92	3.50
26	Less than 25 cubic feet per second	108.63	387.04	102.69	6.20

A commonly accepted estimate of the loss from ordinary unlined canals in earth is 25 per cent of the amount of water passing through the head gate, and from the results of measurements given this estimate seems to be conservative. The additional loss in the laterals and field ditch is usually as much more, so that as a rule, for every gallon of water that is taken from a stream only one-half reaches the fields to be irrigated. The portion which percolates through porous material is not always wasted. The seepage from one canal may be obtained by another at a lower elevation. On the other hand, seepage waters frequently do no end of damage to low-lying lands and the benefit gained by a second diversion and use is more than offset by the damage done in water-logging soils.

LOSSES ARISING FROM IMPERFECT WATER-RIGHT CONTRACTS.

In the large majority of canal contracts, the canal company agrees to supply a stream of a given size continuously or in rotation for the irrigation of a definite tract of land. In the event of a shortage of water each water-right holder receives only his pro rata share of the water available. Since each water user is expressly forbidden by the terms of the contract to use the water thus purchased on any land other than that specified, there is no inducement for him to economize by using less than the amount stated in the contract.

This form of contract was popular at a time when water was cheap and abundant, and in consequence the water allotted to each acre is usually far in excess of the actual requirements of the crops when the subsoil becomes partially filled with waste water.

In some of the more recently organized irrigation companies the water is measured out to each user and he pays only for what he gets. Such contracts place no limitations on the place of use. In the most common form of contract the self-interest of the irrigator leads him to waste water by applying too much; in the later form his interests are best served by the strictest economy. If in future all companies organized for this object could be induced to sell water by measurement, requiring the user to pay a quantity rather than an acreage rate, much water could be saved. Most farmers who now use and waste every summer sufficient water to cover their fields to a depth of 4 feet under the old system would find that they could produce more valuable crops with the use of 2 feet under the form of contract herein recommended.

LOSSES DUE TO UNJUST AND IRREGULAR DISTRIBUTION.

The large majority of rights to the use of water has never been determined by a competent tribunal. In consequence, disputes among neighbors over the quantities each is entitled to are common. Such uncertainty leads to overreaching and injustice. When one man takes twice as much water as properly belongs to him his neighbor may have none. To insure a supply it is usually necessary for one man to stand guard over the headgate while his comrade tends to the irrigation of the field. Under such conditions it is impossible to use water to the best advantage and in the most economical way.

LOSSES FROM POORLY PREPARED FIELDS.

The surface of the fields is rarely prepared with that skill and care which rapid and effective watering demands. A thorough grading and smoothing of the surface is necessary before water can be evenly distributed over the surface. Failure to prepare the surface properly results most frequently from carelessness, because money and labor thus spent bring in large returns. In addition to the amount of water saved, the labor of irrigating the properly prepared field is lessened, the soil is not damaged by an overdose of water in the low places, there is considerable increase in the yield, and the quality of the crop is improved.

LOSSES IN THE APPLICATION OF WATER.

These losses are due to carelessness and unskillful use, evaporation from the wet soil, and percolation beyond the reach of the roots of plants. All of these losses are increased when the surface is not properly graded, but even in well-graded fields it is possible to lose a large part of the water which is delivered at the highest point by unskillful use. The application of frequent light irrigations on the surface tends to keep the surface moist the greater part of the time, and in consequence much of the moisture is evaporated. In the best methods of applying the water the losses due to evaporation will be considerable unless frequent cultivation is resorted to. Deep percolation is another source of loss. When the subsoil is porous it is difficult to prevent, even under the best practice, considerable quantities from percolating to depths far beyond the deepest roots. On the other hand, in stiff retentive soils there is not sufficient percolation, and under careless use a large part is allowed to flow off the surface and pass beyond the tract to be watered.

THE RELATION OF IRRIGATION TO FORESTS.

In Bulletin No. 38 of the Utah Agricultural Experiment Station, the beneficial effects of forests in increasing the water supply is set forth in the following words:

> The municipal engineer increases the size of sewers which drain areas covered with an impervious lining, such as the roofs of buildings, paved streets, and cemented sidewalks. He well knows that if a heavy rain falls on such a district, the greater part will immediately run off and the sewer must be made large enough to carry this flow. The same amount of rain may fall on lawns, vacant lots, or porous streets without producing more than 40 or 50 per cent of the maximum discharge.

> In like manner, when rain falls on a mountain slope that has been denuded of its natural forest growth, there is little, if any, vegetable mold to absorb and retain, for a while, the moisture. The rain drops fall on the rocky surface, gather into rills, and these into streams, until a mountain torrent is formed. These intermittent streams that flow with great rapidity are in nearly every sense detrimental to the irrigator.
>
> On well-wooded mountain slopes the case is different. Here the leaf mold of centuries absorbs and holds back the rainfall, and weeks or even months afterwards some field or orchard far down in the valley may be invigorated by its presence. Here, too, the winter snow finds a resting place, sheltered alike from wind and sunshine. The heat of spring melts the snow gradually and permits a large part to sink into the vegetable mold, from which it is gradually conveyed beneath the surface to do good service to the irrigators of the plains.

In the foregoing brief paragraphs are set forth the chief benefits of forests in equalizing the streams. It is not true, as some contend, that forests increase the water supply. The vegetable matter which covers forests not only retains a large part of the natural precipitation but also no small portion of the melting snows in seasons of the year when water is abundant and possesses little or no value. The water which is thus held back in these natural storage reservoirs usually seeps, in course of time, down the mountain slopes and forms the chief source of late summer and autumn stream flow. Vegetable mold also prevents the loss of water by evaporation from the surface. Many experiments have been made to determine the effect of such mulches in preventing evaporation, and almost without exception all go to show the beneficial effects of such a mulch.

The part which forests play in equalizing the water supply, holding back a portion of the spring floods and delivering the greater part of the water thus stored later on in the season to feed the springs at a lower elevation, is well understood and has been fully presented of late in a large number of publications relating to forestry and irrigation.

There are, however, other phases of the subject which should not in fairness be overlooked. One of these is the effect of deep, compact snowdrifts which lodge in ravines and melt slowly during the summer months. There is no question that most of the water supply which is derived from this source is usually accredited to the beneficial effects of forest growth. Any one who is familiar with the main ranges of the Rocky Mountain region has noticed large accumulations of compact snow in the deep ravines of the mountains during the summer and autumn months when all the snow has disappeared from the forests. Men who have closely observed the effects of these snowdrifts are led to believe they conserve more water than the forests.

There is another phase of this subject which deserves a passing word. That is the large amount of water required to nourish forest trees. It is well known that every plant, whether it be a stalk of grain or an orchard tree, requires a large amount of water to maintain a healthy growth. The same is true of forest trees, with this difference, that as their transpiration surface is much greater, much more water is required. When this water is withdrawn from the soil in seasons of scarcity it must tend to greatly reduce the quantity of water which reaches the streams in the immediate neighborhood.

THE RELATION OF IRRIGATION TO FLOODS.

The quantity of water diverted from streams in flood time for the irrigation of land is usually so small in comparison to the stream itself as to produce little or no effect in lessening the flow or in preventing destructive action by floods. While this has been generally recognized, the building of storage reservoirs for such purposes has been quite generally and persistently advocated for a number of years. Many prominent men outside of the engineering profession and quite a number of hydraulic engineers have advocated this means of controlling flood waters. They claim that if the water of streams and their tributaries which are subject to destructive floods were diverted into mountain reservoirs, the withdrawal of so much water would greatly lessen, if not altogether prevent, the floods. In advocating a plan of this character they have failed to outline any practical way in which it can be done. It is not likely that storage reservoirs will ever be built for the sole purpose of preventing floods. The cost will be prohibitive. This may be illustrated by reference to the Sacramento River in California. This river is quite small in comparison with others subject to floods, but to have provided storage for the discharge of this stream below the mouth of Feather River for twenty-four hours on March 19, 1907, would have cost at least $20,000,000. When one remembers that this flood lasted for four days with extremely high water, both before and after this period, the magnitude of the undertaking is apparent. Furthermore, the rapid filling up of such reservoirs with silt borne by flood waters would gradually reduce their capacity. In nearly every case experienced hydraulic engineers are of the opinion that for purposes of river control it would be much more economical to provide a passageway for flood water by means of levees and channel excavations than to attempt to hold the water behind costly dams at the higher elevations.

If it is intended to build storage reservoirs to provide water supplies for the irrigation of lands and at the same time utilize them as occasion arises for the prevention of floods, the plan is not feasible. There would be diverse interests that could not be brought together. The landowners in the more elevated portions of a drainage basin would want storage reservoirs solely for irrigation purposes. Those in the lower portions of the basin would want them most for protection against overflow. One and the same reservoir could not well serve both purposes. The irrigator would never consent to take chances on a half-filled reservoir for the sake of keeping it empty to provide for a flood which might never come.

IRRIGATION LAWS AND ORGANIZATIONS.

By R. P. Teele,
Office of Experimental Stations.

WHAT AGENCIES ARE DEVELOPING IRRIGATION.

INDIVIDUAL.

The early irrigation works were built almost entirely by individuals or groups of individuals working together, who built small works, taking water from streams for the watering of their own lands. This type of development is past in most arid sections, because the opportunities for it are fully utilized, but in the semiarid region it is probable that large areas will still be watered in this way, as the advantages of irrigation in sections where crops can be grown without it are realized. Irrigation by individuals, however, has still a very large field where water is pumped from wells or stored in small reservoirs, which are filled from the torrential flow of streams or with rainwater collected from adjacent lands.

Most large ditches cover more lands than can be irrigated by them, but they raise the level of the ground water to such an extent that it can be pumped to the surface within the limits of allowable cost. A great many such pumping plants have been, and are being, installed by individuals, and there is great opportunity for extension along this line. The pumping of water from the soil in this way produces a double use of water, for the source of supply is water already used for irrigation. While in some sections of southern California and southern Texas large areas are irrigated with water pumped from underground sources, it is generally true that this source is just beginning to be utilized. This field is peculiarly adapted to development by individuals because of the many advantages of pumping water at the point of use, the greatest of which are the saving of the expense of building conduits to carry the water to the place of use and the avoidance of all losses of water in transit, which losses are very large if water is carried in earthen ditches, and which can be prevented only at heavy expense. It is true that small pumping plants are not so efficient as larger ones, and this is especially true of engines of all types. However, the long-distance transmission of electric power makes it possible to develop power in large central stations where conditions are especially favorable and distribute it to individual or neighborhood pumping plants. In this way the cost of power is reduced to a minimum, as the electric motors and pumps used by the farmers require almost no attendance, leaving the farmer free to attend to his other duties.

The storage of storm water in small reservoirs is another field of great possibilities which belongs naturally to the individual and which has been barely touched as yet. The opportunities for such development are greatest on the plains where stock raising must always be the principal industry. In the past, great areas have been unused because flocks and herds must be kept within the reach of water. The storing of the storm water makes it possible to use great areas formerly unavailable, and it also enables the stockman to raise forage for feeding during winter storms, thus preventing the losses due to starvation when winter feed is not supplied, which losses often reach 10 per cent in a single storm. The greater part of the plains area is beyond the reach of water from streams, and underground water is at such great depths that the cost of pumping it to the surface is prohibitive, but these plains have innumerable ravines and depressions in which storm water can be stored at small expense.

The small precipitation of the plains for the most part comes in heavy showers which run off quickly, causing floods in the usually dry drainage channels, which do great damage. If this water can be held back in reservoirs they will serve the triple purpose of providing stock water, irrigation water, and checking floods. This work has been begun and has proven its value, as shown by instances cited in a report on this subject published by the U. S. Department of Agriculture.[a] No other one thing promises so great returns from the Great Plains lying to the east of the Rocky Mountains.

Since storage dams are always a menace to land lying below them, the construction of such dams should be under the supervision of competent local officials who should be empowered to prescribe rules for their construction, to inspect them during and after construction, and to order necessary changes and repairs. The National Government is aiding in this work through the United States Department of Agriculture, which has published bulletins showing the possibilities of such storage, the returns secured, and the methods of construction which should be adopted to insure the permanency of dams and protect the land below them from damage. Any law enacted by the General Government providing for the leasing of grazing areas should provide in some way for the encouragement of the building of storage reservoirs and should permit the cultivation of a small part of each leasehold.

CORPORATE.

Following the individual and partnership ditches, which watered a single farm or a few neighboring farms along the rivers, came the large ditches built by corporations to water the higher lands of the river valleys of the arid region. These corporations have built most of the large ditches now in use. The great increase in the value of desert lands, when water was supplied for their irrigation, attracted large amounts of capital into this field in the years immediately preceding and following 1880.

The prevailing type of corporation was a company which built the irrigation works and sold water rights to settlers, the expectation being that the sale of water rights would repay the cost of construction with a good profit, and leave the company still in possession of the works and franchises, the contracts with the water users providing for the payment of annual charges to cover the cost of maintenance and operation. The promoters thus expected to secure the return of their entire investment, retain the property, and make it pay interest on its cost. Almost without exception these companies have been financial failures, but agricultural successes. The lands were settled slowly, so that water rights were not sold; maintenance charges were based on the entire acreage to be irrigated, and the payment from the small areas watered did not begin to cover the cost of maintenance and interest charges. Meanwhile the farmers prospered, and eventually the lands were settled but not until interest and upkeep had brought financial ruin to the companies building the works.

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[a] O. E. S. Bul. 179—Small Reservoirs in Wyoming, Montana, and South Dakota, by F. C. Herrmann.

A modification of this plan which became very popular was a provision that when all or a large percentage of the water rights represented by a canal were sold the works were to become the property of the water-right holders, to be maintained and operated by them. The water-right contracts were to be exchanged for stock in a new company which should take over the works and operate them. This has not proven much more successful, from the standpoint of the original investor, but it has resulted in making this the prevailing type of canal company throughout the arid region. By far the larger part of the existing irrigation works in the arid region is owned and controlled by stock companies, the stock of which is in the hands of the water users. The laws of all the States accepting the conditions of the Carey Act, and the reclamation law, providing for the construction of irrigation works by the General Government, provide that the works built shall be turned over to companies of this type. In general, then, this may be said to be the standard type of irrigation corporation. There are some companies which supply water to customers without the sale of water rights, securing their entire returns from the annual charges. These are most common in the rice districts of Louisiana and Texas, although they exist in other places.

In all of the arid States canal companies are given the right of eminent domain, and the States have the right to regulate charges, usually through the county commissioners.

There is still considerable construction being carried on by canal companies of the types just described, but the greater part of present construction is done by quasi-public corporations under state control, or by the National Government under the reclamation law.

STATE.

In two instances States have undertaken directly the construction of irrigation works, but in both instances the undertakings have been abandoned. Colorado sought to utilize its convict labor in the building of ditches, but abandoned the attempt before completing any works. Montana attempted to build its own ditches under the Carey Act, but here, too, direct state construction was abandoned before any projects were completed.

The arid States do, however, aid in the development of irrigation under two classes of laws: Irrigation district laws, and laws accepting the conditions of the Carey Act.

IRRIGATION DISTRICTS.

Irrigation districts are given the power, when properly organized, to issue bonds to secure funds for the purchase and construction of irrigation works; to levy and collect taxes for the maintenance and operation of these works, for the payment of interest, and for the creation of sinking funds to pay off the bonds issued. They are organized under public supervision, and provision is made for the establishment of the validity of their organization. The bonds and the taxes levied are liens upon the lands of the districts in the same manner as are county and state taxes. Usually county treasurers are ex-officio treasurers of irrigation districts within their respective counties.

The irrigation district laws of the several States are similar in a general way, but differ much in detail. They provide that the lands susceptible of irrigation from a common source and by the same system of irrigation works may be organized into an irrigation district. Usually the organization of an irrigation district is to be initiated by petitioning the county commissioners of the county in which a majority of the lands are situated. When the plans have been formulated and the proposed boundaries have been fixed an election is held to decide upon the organization of the district. The qualifications of electors differ, the Colorado law being as follows:

> All persons shall be entitled to vote who are resident freeholders of agricultural lands within said district, or who are owners of lands to the extent of 40 acres or more within said district and reside within any county into which any part of said district shall extend, and who are qualified electors under the general election laws of the State, and who shall have paid property taxes on property located within the district during the year preceding any such election. (Laws of 1907, p. 488.)

The majority required to carry such an election also varies in the different States. In Colorado a majority vote only is required for either the organization of a district or the issue of bonds. In Idaho a two-thirds vote is required for either purpose.

The manner of assessing the cost upon the lands also varies. In Colorado it is a flat rate per acre; while in Idaho the cost is apportioned in proportion to the benefits received, while the cost of maintenance and operation may be provided for by tolls or by assessments on the lands, or by a combination of the two.

The bonds run twenty years. Only the interest is payable during the first ten years. At the end of the eleventh year 5 per cent of the bonds mature; at the end of the twelfth year, 6 per cent; at the end of the thirteenth year, 7 per cent; fourteenth year, 8 per cent; fifteenth year, 9 per cent; sixteenth year, 10 per cent; seventeenth year, 11 per cent; eighteenth year, 13 per cent; nineteenth year, 15 per cent; and twentieth year, 16 per cent.

Irrigation-district laws have been used principally for the purchase of works already built and for their enlargement or extension. They are not adapted to the construction of new works in the arid region because a large part of the lands to be reclaimed belongs either to the General Government or the States and can not be taxed for irrigation-district purposes, and consequently can not become security for the bonds of districts. To obviate this objection as far as possible Idaho provided by law that state lands included within irrigation districts should be liable for district taxes, and that the taxes paid by the State should be added to the price of these lands when sold by the State. Idaho provided also for the purchase of irrigation-district bonds by the General Government under the Reclamation Act. However, neither of these provisions has had opportunity to demonstrate its utility.

They suggest, however, the possibility of adapting these laws to the development of new lands and point out an existing weakness in other forms of organization. The building of a canal from which a tract of land can be supplied with water greatly increases the value of the land. Under the usual forms of canal organization the owner of land under a canal may or may not purchase water rights, but the value of his property is greatly enhanced by the mere possibility of securing water. Yet there is no way in which he can be made to contribute to the cost of the irrigation works. This condition was one of the primary reasons for the passage of irrigation-district laws. Under them all private lands susceptible of irrigation from the work built must contribute to the cost. The taxes levied by the district can not be met from unimproved lands, and improvement of all lands covered is therefore forced. Lands owned by the State or General Government can not, however, be made to contribute. It seems that both the States and the nation should provide for the payment of district taxes on their lands, with proper provision, of course, for approval of plans by public officials, for the addition of taxes paid to the price of the public land, and limitations upon the percentage of public land in the total area of a district.

District laws have a further advantage in that payments on the bonds for the first ten years are limited to the interest, whereas other laws require that payments on the principal begin at once. Often the preparing of land for irrigation costs as much as the irrigation works and is a heavy burden on the settler during the first year of his settlement. Under district laws he is free to meet these expenses and pay the cost of his irrigation works when he has become established.

District laws place the control of irrigation works in the hands of officials elected by the owners of the lands watered, the difference between this control and that of the stock companies previously described being that in the district all landowners have equal voice in the control of the works, while in the stock company the stock and the influence of its holder are usually in proportion to the acreage watered.

THE CAREY ACT.

Under what is known as the "Carey Act" (an act making appropriations for sundry civil expenses of the Government for the fiscal year ending June 30, 1895, and for other purposes, 28 Stat., 372–422) large areas have been developed under a sort of cooperation between the nation, the State, corporations, and individuals. The General Government gives the lands to the States on condition of their reclamation; the States enter into contracts with corporations to reclaim these lands, and sell the lands to individuals.

Section 4 of the act above mentioned, which constitutes the so-called "Carey Act," provides for the granting to each of the arid

States free of cost for survey or price such areas of desert land, not to exceed 1,000,000 acres, "as the State may cause to be irrigated, reclaimed, occupied, and not less than 20 acres of each 160 acres irrigated by actual settlers," within ten years from the passage of the act.

In 1896 Congress passed an act providing that a lien might be placed on these lands to secure the payment of the cost of the irrigation works built to reclaim them, and in 1901 the time limit contained in the original act was removed, the law providing that the ten years within which lands must be reclaimed "shall begin to run from the date of approval by the Secretary of the Interior of the States' application for the segregation of such lands," and giving the Secretary of the Interior authority, in his discretion, to extend this time for an additional five years.

Further modification in 1908 granted to each of the States of Wyoming and Idaho, which had applied for most of the original 1,000,000 acres allotted to them, an additional 1,000,000 acres.

The conditions of this act have been accepted by the following States: Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming.

The plans adopted by the States for carrying out the reclamation of these lands vary in details, but are similar in their general outlines. The system adopted by the State of Wyoming is described by the state engineer as follows:

> The company proposing to carry on such development first makes its surveys and plans for this work; then secures the necessary permits from the state engineer's office; then makes its request and proposal to the state board of land commissioners, composed of the governor, the secretary of state, and the superintendent of public instruction. This request and proposal describe the lands that are to be irrigated and contain the proposition of the company to the State as to price of water rights and a permanent interest in irrigation works, the form of contract to be used, and other particulars. If the state board of land commissioners approves the proposition, maps and a request for the segregation of the lands are transmitted to the proper local land office. The lands designated are immediately withdrawn from entry, and the local land office submits the request to the General Land Office at Washington, where the approval of the Secretary of the Interior finally places the State in control of the land. The works are then completed by the company. The land can not be taken up until the settler shows the State that he has entered into contract with the company for a sufficient water right for his lands and a perpetual interest in the irrigation works, proportioned in the ratio of the area of his land to the entire tract to be reclaimed. When the irrigation works are completed, the state engineer makes an inspection, and if they are found to comply with the plans and specifications which have been already passed upon by him, the state board of land commissioners is so notified; whereupon the board makes a request to the Government that patent issue. The patent comes to the State, and the lands are sold and patent given the settler upon the payment of 50 cents per acre, the payments for water rights being made to the company building the works.

The areas segregated and the areas patented to the States under the Carey Act up to July 1, 1908, as shown by the report of the Commissioner of the General Land Office, are as follows:

Segregations applied for under the act of August 18, 1894 (28 Stat. L., 372–422), and the acts amendatory thereof, with the action taken thereon, from the passage of the act to July 1, 1908.

[Areas in acres.]

State.	Selected.	Rejected, relinquished, etc.	Approved, not patented.	Approved and patented.
Colorado	59,807.94	5,704.95	54,102.99	....
Idaho	1,180,566.17	265,828.94	662,254.00	186,954.90
Montana	104,587.98	2,792.53	83,498.54	18,296.91
Nevada	12,644.61	8,000.00	....	....
Oregon	432,202.53	78,507.31	245,287.52	50,063.13
Utah	328,327.40	236,980.83	48,226.74	....
Washington	155,649.20	155,649.20	....	....
Wyoming	965,568.64	196,994.18	623,054.44	7,768.72
Total	3,239,284.66	952,458.13	1,716,424.23	263,083.66

Oregon segregation list No. 5, covering 58,344.57 acres, is pending before the Secretary on appeal from the decision of this office rejecting it.

Wyoming segregation list No. 27, covering 26,936.03 acres, was rejected by this office, which decision was affirmed by the department, but said decision has not yet become final.

As before stated, Congress in 1908 granted to Wyoming and Idaho, the only States which had applied for nearly the entire original allotment, additional areas of 1,000,000 acres each, indicating an intention to extend the area indefinitely as there is a demand for it. This seems to be a wise attitude.

The object of all our land laws has been to get the public lands into the hands of those who will make homes on them, rather than to secure a revenue from them. The Carey Act has proved well adapted to that end, and so long as it does this there seems to be no reason why there should be any limit on the area which may be selected by each State under this law.

The laws of all the States provide that when the water rights are sold and paid for the works shall become the property of the water-right holders and shall be turned over to a company composed of these parties to be maintained and operated by them, the provisions in this regard being similar to those of the reclamation law.

NATIONAL.

(Discussion of reclamation law omitted on account of its being under another department.)

DO PRESENT LAWS TEND TO PROMOTE IRRIGATION FULLY AND WISELY?

The object of all our laws relating to irrigation is to secure the establishment of the largest possible number of permanent prosperous homes on the lands of the arid region. All these laws must be judged by this standard. The establishment of homes in the arid region requires the cooperation of three parties—capitalists, farmers, and the public—and the interest of each must be guarded in any successful system of irrigation law. The capitalist must be given reasonable security for the return of his investment; the farmer must have a reasonable guaranty of a water supply and must be protected from exploitation by the capitalist; and the public must be assured that its resources will be economically used.

SECURITY FOR CAPITAL INVESTED.

As pointed out in the discussion of agencies now developing irrigation, the day of enterprises carried out by the individual is past. The construction of the large irrigation works necessary to store and divert the water of the large streams of the arid region requires the investment of large amounts of capital, and in order that this may be put into these enterprises it must have at least as great a degree of security as exists in other lines of investment. This security depends upon both the farmers and the public. The builders of irrigation works must be given a lien upon the property values created by these works sufficient to guarantee a return upon their investment, and in order that these property values may be stable and therefore good security, the water supply on which these values rest must be guaranteed within reasonable limits.

The three agencies under which the largest development is now taking place are: Irrigation districts, the Carey Act companies, and the United States Reclamation Service. Under the irrigation-district laws capital is secured by the sale of bonds, which are a lien upon the lands of the districts, and under the Carey Act the companies building the works sell water rights, the deferred payments on which become liens upon the lands. Under the reclamation law the Government secures itself by taking liens upon the lands. It seems, then, that under these laws capital is amply secured so far as the farmer is concerned, and the large amounts of capital being put into irrigation works under all these laws indicate that the security is considered sufficient.

This security is almost valueless, however, unless the water supply is reasonably sure, since the lands of the arid region are rendered valuable only by the use of water. This has been recognized from the earliest settlement of the arid region, and the legislatures and courts of the arid States and of the General Government have been trying from that time to this, to develop a system of laws which will render rights to water as secure as those to other forms of property. In order that this property may be as secure as other property, two things are essential: That all rights be defined, and that some effective system of protection be provided. There are in the arid region two systems of water law, one of which fulfills these requirements, and the other of which renders any such security impossible.

Certain States have recognized the common-law doctrine of riparian rights, which, in the very nature of the doctrine precludes any defining of rights. The riparian owner is held to have the right to a reasonable use of the water of the stream to which his land is riparian, which use must not interfere with a like use by all other riparian owners. What is a reasonable use at one time may not be at another time, and any riparian owner may at any time enlarge or change his use of the water, every change making necessary a new adjustment of use by all other owners. As a result, there can be no security of rights where riparian rights are recognized, except through monopoly created by the uniting of ownership in a single party. Some of these States have enacted laws providing for the condemnation of riparian rights, and this seems to be the only equitable way in which the handicap created by the recognition of riparian rights can be overcome.

Most of the arid States have either abrogated the doctrine of riparian rights or their courts have held that it never existed within their territories because of its inapplicability to arid conditions. These States allow the diversion of water from their streams for the irrigation of any lands, whether riparian or not. They have adopted the principle that "the first in time is the first in right," which in practice means that the one first using water from a given source has a right to continue that use to the extent of the original use, as against anyone taking water from the same source at a later date, and that when there is not water enough to supply all demands the latest user is first deprived of a supply, and so on, in order as the supply decreases. The carrying out of this system requires that all rights be defined as to both time and extent, and an administrative system to divide the water among those entitled to its use, according to their respective rights. These States have provided for the defining of rights either by the courts in a special procedure, or by administrative boards, with appeal to the courts. They have provided for either the granting of rights by the State or for the securing of rights by appropriation, which are later defined by the courts; and they have provided for the distribution of water in accordance with these decrees by state officials. This system gives the necessary security to water rights. The records of the state officials show what rights are already in existence; they show whether the stream flow is sufficient to satisfy existing demand, and whether there is more water to be secured by the builders of new ditches or reservoirs; and state officials distribute the water. There have been, of course, many crudities in court decrees, and injustice has been done in some cases, but the system is good, and should be maintained. One serious weakness has developed in this system. The courses of many of our large streams lie in more than one State, and the administrative system of a State can not extend beyond its boundaries. This weakness has been met so far by appeal to the United States courts. There has been strong demand for some administrative provision for the distribution of water from interstate streams, but no such provision has been made so far. The United States courts have uniformly upheld the doctrine of priority, regardless of state lines, and have protected the users in the lower States against later users in the upper States. A physical examination of our interstate streams leads to the conclusion that there is not likely to be serious conflict between the States on these streams. In most cases the physical conditions are such that users in the upper States can not do serious permanent injury to the users in the lower States.

In general, therefore, from the standpoint of the capitalist, the existing water laws of the arid States, except those which have recognized riparian rights, give the necessary protection to water rights.

PROTECTION FOR THE FARMER.

As regards the water supply, the canal company stands in the same relation to the farmer that the State does to the canal company. There has not been, however, the same provision for the protection of the rights of the farmer. Many canal companies have agreed to supply water to far more land than their canals will serve properly, and have inserted in their agreements provision that whatever water their canals receive shall be prorated among all holders of water rights, and that they are not responsible for any shortage due to causes beyond their control or to shortage in the source of supply. A common provision in such agreements is that the company will not sell rights to more than the "estimated capacity" of its ditch, but this is little protection, because there is no limit put on the "estimate" of the ditch owner. While such provisions have worked many hardships on the farmers they have tended to an economical use of water, because farmers under canals supplying insufficient water have been compelled to practice a degree of economy which they might never have attained except under necessity. There should be legislation by the States making canal companies responsible for shortages due to overselling, because the new settler, coming into an arid region is in no position to determine for himself whether the company selling him a water right is in a position to furnish him a full supply.

As pointed out in the discussion of agencies developing irrigation, the prevailing type of ditch company is one in which the works ultimately become the property of the water users, and that irrigation-district laws, the Carey Act, and the reclamation law all provide for the control of the works by the water users. None of these laws protects him, however, from purchasing an interest in a canal which will not supply him with sufficient water. He guarantees his payments for these works with a lien upon his lands, but has no recourse if he is not supplied enough water to enable him to raise crops with which to meet his payments.

THE GUARANTY OF ECONOMICAL USE.

Throughout the arid region, except in the States which recognize riparian rights, the extent of a right to water is the quantity which has been put to a beneficial use, and the right ceases to exist when the use is abandoned. In some States the period of nonuse which constitutes abandonment is fixed by law, while in others this is left to the courts. These laws, if properly enforced, effectively prevent the holding of rights unused for speculation, as land is so often held.

These States have also laws prohibiting the waste of water, and as a rule the officials charged with distributing water are required to prevent waste, but in practice this is extremely difficult, since the officials can not patrol the ditches, but must turn out to each canal the water which its owners demand within the limit of their rights. These laws do, however, usually prevent absolute waste. But between positive waste and the most economical use there is a very wide margin for saving, which can be realized only by making it to the interest of the water user to be economical.

Considered from the standpoint of their influence on the economical use of water, the laws of the arid States fall in two classes—those which allow the acquirement of rights to fixed quantities of water and those which allow the acquirement of rights to water sufficient for fixed areas of land. It has been found that the granting of rights to fixed volumes of water with the privilege of using this water on as much or as little land as desired brings about the most economical use of water. Having a certain volume of water, it is to the interest of the owner to secure as large a return as possible from this supply. On the other hand, the water user who is entitled to sufficient water for a certain area has no incentive to economy. His saving brings him nothing, but goes to some one else. Under these circumstances he can not be expected to spend time or money in saving water, as he would do if his efforts enabled him to water more land and thereby increase his returns.

The fear of the accumulation of rights in the hands of nonusers or "water lords," and of their exploitation of the water users has led to the enactment of laws attaching rights to particular tracts of land, to the prohibition of the ownership of water rights apart from the land on which the water is to be used, and to the limiting of rights to the needs of these areas. But in practice it has not proven satisfactory. It has been found necessary to provide for the transfer of rights from the areas in connection with which they were acquired to other lands, the needs of which may or may not be the same as the needs of the areas from which the rights are transferred, thus rendering all rights uncertain as to quantity, and encouraging the liberal use of water in order to be sure and always have enough. It has been shown in the preceding discussion that there has been no tendency to "water lordism," but that the prevailing type of canal organization is the stock company composed of the water users, while all the laws under which development is now taking place provide for placing the ultimate ownership and control of irrigation works in the hands of the owner of the lands served. It is believed, therefore, that the reasons which brought into existence the laws attaching rights to definite areas of land and measuring them by the necessities of these lands have ceased to exist if they ever did exist. It is believed that the only system which can be expected to lead to the economical use of water is the limiting of rights to definite quantities of water, leaving the water-right holder to use this on as much or as little land as he will.

UPON WHAT MODIFICATIONS OF LAW WILL THE BEST PERMANENT DEVELOPMENT OF IRRIGATION SYSTEMS DEPEND?

Modifications of existing laws have been suggested in the preceding discussion. These suggestions lead to the following definite recommendations:

FEDERAL LAWS.

Limited areas of public lands within the area of irrigation districts should be made liable for irrigation-district taxes, the taxes thus paid to be added to the selling price of the lands.

The provisions of the Carey Act should be extended to the Territories, and the limit of the area which may be selected by each State should be removed.

The reclamation law should be amended by providing for extensions of time for payments on water rights whenever a full supply of water is not available, and for release of mortgages in case the shortage is permanent.

STATE LAWS.

The law of riparian rights, so far as it is recognized in the arid region, should be abrogated, allowing the use of water on all lands, whether they border on streams or not. In this, vested rights should not be injured, but should be condemned for the public good. A permanent settlement of rights seems to be impossible until this is done.

Those States which have not already done so should provide for the defining of existing rights to water, for the orderly acquirement of rights in the future, and for the division of the water of streams among those entitled to its use by public officials.

Laws should be enacted prescribing severe penalties for selling rights to more water than can be supplied, since settlers have no means of ascertaining the ability of a canal company to fulfill its contracts.

All rights to water should be based on quantities rather than areas, since only in that way can economical use be secured.

State lands within the limits of irrigation districts should be made liable for district taxes, with proper limitations as to the proportion of the whole area which may be state lands, and for approval of district plans by state officials; the taxes paid being added to the price of the lands when sold.

UNDERGROUND WATERS.

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Underground waters constitute one of the three natural subdivisions of precipitation. These subdivisions are evaporation, surface run-off, and percolation. That part of the precipitation which passes below the soil surface by seepage into the soil pores becomes thereby a part of the body of underground waters. Eventually it is returned to the air to begin again its circuit through the air and back to earth. This return to the air may be accomplished very quickly or very slowly. Capillarity and evaporation may withdraw the earth moisture and return it to the atmosphere before it has reached any considerable depth in the soil mantle, or it may pass beyond the reach of these forces and begin a journey through the soil pores or the rock masses that may continue for a few hundred feet or a few hundred miles. The waters may even accumulate in a porous rock mass and may remain there stored and practically motionless for centuries or for geologic epochs. All of that portion of the precipitation that is absorbed and remains underground for either a long or a short period, following a long or a short course, constitutes the ground water. There is, in addition, a certain amount of original water, either magmatic or included with the sediments at the time of their deposition. The aggregate quantity of this is undoubtedly very great, but as it is in general inaccessible to man, little attention need be given it in a discussion of water as a resource.

An estimate of the quantity of surface waters is a large but a relatively simple problem. It can be solved by the patient application through long periods of well-determined engineering methods. The resulting estimates, since they are those of the engineer and the mathematician, are correct within a limited percentage of error, because all the factors of the problem are capable of close determination. But although the quantity of surface waters is measurable, its maximum possible use is not rigidly determinable, because that problem contains a number of variable factors. Man's mastery over the mechanic arts is constantly increasing. That which is impossible to him to-day becomes possible to-morrow. Furthermore, economic controls are constantly shifting. A water power that is not available this year, not because of unsolved mechanical problems, but because of cost, may be easily available next year, because a railroad has been built, or a mine has been opened, or population has shifted. These are things that neither the mathematician nor the economist can predict. They introduce into the problem of determining the possible future use of any resource a factor so variable that the result is of doubtful value. Suggestions only can be made; rigid determinations are not possible.

As to ground waters, neither the determination of the total quantity nor of the maximum use is capable of close solution. The first involves general estimates of factors not directly measurable, such as the percentage of pore space in deeply buried and inaccessible material, soils, and rocks. These estimates must be made by the deductions of an inexact science, geology, instead of through the measurements of an exact science, engineering. The same variables enter into the determination of the maximum possible use of ground waters as into the maximum possible use of surface waters, namely, different and constantly shifting economic controls. It may be highly profitable to pump ground waters 500 feet vertically for the irrigation of citrus lands in southern California whose product is worth $250 per acre per year, whereas it may not be possible to pump 50 feet vertically in another locality, where the products are not worth $10 per acre per year. Notwithstanding, some such crude estimate as may be made of the quantity of these resources is helpful, since it gives us a concrete conception of the amounts with which we are dealing.

QUANTITY.

Estimates that vary widely have been made as to the total amount of this ground water. These estimates range from an amount sufficient to cover the earth to a depth of 96 feet (Fuller) to an amount sufficient to cover it to a depth of 7,500 feet (Delesse). The lower estimate is the later and may be regarded as of the greater value. The determination of the total quantity of underground water in existence, however, while a question of scientific interest, is of no practical moment, since only a very small proportion of the total is accessible to man and can therefore be made use of by him. And again, of the relatively small amount that is within reach, only that proportion that, if withdrawn, will be restored annually can be utilized, because, obviously, withdrawals in excess of this mean reduction of the principal and eventual bankruptcy.

Hence, although impressive estimates of the total may be made—as, for instance, the statement that there are 600 cubic miles of potable ground waters beneath the State of Florida, 800 cubic miles in the Great Central Valley of California, 1,000 cubic miles in the Dakota sandstone aquifer, and 10,000 cubic miles in the sediments of the Atlantic and Gulf coastal plains—these statements are not merely valueless, they are sadly misleading, because, if issued without explanation, the inference would follow that such a tremendous amount of water could be extracted from these districts and used by man. This inference is wholly unjustified for a number of reasons. In the first place, only a limited although variable percentage of the water that saturates those parts of the rock or soil masses that are within reach of pumps can be extracted in development; the remainder, much the larger proportion, being capillary and subcapillary, is not capable of extraction in any commercial way.

Again, these estimates of total ground waters include those at great depth, utterly beyond the reach of any pumps or known devices for their recovery. And, finally, of the very small proportion of the total that can be brought to the surface and made useful to man, only an amount should be taken out that is equal to the annual restorations; otherwise there will be a gradual depletion of the supply and a corresponding increase in the cost of the product. Hence, as a practical people, we are not in the least concerned with the total quantity of ground waters, but only with the possible annual accessions to the total, for this controls use.

USE.

The use of ground waters in a limited way for domestic and farm supplies is well-nigh universal. Municipal use, although not so general, is also extensive; whereas use for irrigation, confined, of course, to the arid and semiarid States, has begun to attract attention only since power development, either by the utilization of the energy of running water or by means of small power plants of the steam or internal combustion type, has become general. With the imperfect data at hand it is not possible to estimate the total volume of ground waters now used throughout the United States, but it is believed that in Florida at least 2,000 second-feet are developed and in California more than one-half as much. The development in these two States, therefore, representing as they do more than the average development in the East and the West, is about 3,000 second-feet. Florida and California include about 7 per cent of the area of the United States. If the development throughout our domain can be regarded as on the average one-half as intense as in these two States, the total ground waters used if united in one stream would equal twice the volume of the Potomac at Point of Rocks, Md., in 1906, with a drainage area of 9,650 square miles, or if a smaller factor is used and the average intensity of development be regarded as one-third that of the two States named, we reach the conclusion that the ground waters now in use would make a river the size of the Colorado at Yuma, Ariz., with a drainage area of 225,000 square miles. Expressed in still another way, this volume is equal to somewhat less than 1 per cent of the total stream flow in the United States. It is to be clearly understood that this represents only artificial development, a direct product of man's activity, and does not include the natural springs which represent the unassisted return of ground waters to the surface. To these is due a very large although undetermined proportion of the low-water flow of all our streams.

PRESENT TENDENCIES.

One of the late phases of the irrigation movement involves the use of ground waters for this purpose. This movement has been inspired by the success of certain communities that have developed such waters and reclaimed a large acreage by their use. The southern California communities, one-half of whose irrigation is accomplished in this way, illustrate what can be done. In the San Joaquin Valley development of this type is under way and will inevitably be greatly extended. Three hundred second-feet of ground waters are now used there; probably 3,000 second-feet are available and colonies are being continually established and individual settlers are constantly entering the valley who are reclaiming more and more acreage by the use of this resource. In other western valleys, as in Utah and in Arizona, development of the same type is under way. Among the famous ground-water districts is that of the Great Plains, east of the Rocky Mountains, underlain by the Dakota sandstone, that yields some of the largest flowing wells of the United States. Another important district includes parts of Minnesota, Iowa, and Wisconsin, beneath whose surface lie water-bearing beds older than the Dakota sandstone, but the beds are locally quite as important. In these latter States irrigation is not practiced, but the ground waters are of great importance as sources of domestic and municipal supplies. In the Eastern and Southern States, those of the Atlantic and Gulf coastal plains are most favorably situated in regard to their ground-water supplies and in them development is more intense than elsewhere in the East. Attention has already been called to Florida, in which nearly 2,000 second-feet of ground waters are developed, nearly one-half of this amount being used for irrigation and domestic purposes. Mississippi, Louisiana, and Texas have abundant underground supplies extensively drawn upon in certain localities, but capable of much more extensive use. Data are not at hand for estimating the amount withdrawn at present.

WASTE.

Attention is usually first centered upon the use of ground waters by the development of flowing wells in areas where they may be secured. The advantages of a supply of this type are many. The waters usually cost little, they are protected from contamination, the output is regular, at least until development becomes too intense for the supply, and the quality is constant. But in regions in which flowing waters are used for irrigation and may be procured at shallow depths the resource is often shamelessly wasted. More wells are drilled than are needed and the water is used during but a small portion of the year, but is nevertheless allowed to flow with consequent reduction of head and depletion of supply and often in addition direct damage to the lands upon which it wastes. This waste is not so serious in humid regions in which the loss is quickly replaced by rainfall, but it goes on with equal recklessness in arid and semiarid sections in which the damage is irreparable. This waste is often in direct violation of state statutes, framed especially to prevent it. Where ground waters do not flow out upon the surface but are developed by pumping, waste does not take place, since the cost of production regulates automatically the amount of water withdrawn. Irrigation practice under these conditions is always superior, as the water user, paying for each gallon that he applies to his land, reduces this amount to the lowest effective quantity in order to save cost. Hence almost invariably better results are obtained with a lower duty in districts where irrigation water must be pumped than in those in which it flows.

In the humid regions ground waters—almost everywhere available—are particularly useful as sources of farm, domestic, and municipal supplies and for certain industrial purposes. They are especially beneficial and of particularly good quality in the coastal plain of the Atlantic and Gulf States and in the glaciated regions where the mantle of drift or of unconsolidated sediments forms a reservoir of great capacity, whose supply is rapidly renewed when drawn upon because of the abundant rainfall. Outside the coastal plain and the drift-covered areas conditions are variable, but generally they are inferior to those in the regions named, because the soil mantle over the rocks is often thin and irregularly distributed and in addition is frequently clayey and of small holding capacity. Within either of these regions there may occur synclinal basins of porous rock like the St. Peter sandstone and associated beds in Minnesota or the Dakota sandstone in the Great Plains, both of which form most important reservoirs. Usually, also, the fractured upper surface of whatever rock lies immediately below the soil carries a supply that may be drawn upon by town and farm wells.

IMPORTANCE.

The importance of these supplies in humid regions to the dwellers there is illustrated by Mr. Frank Leverett's careful determination of the fact that 75 per cent of the population in Michigan are directly dependent for water upon the underground supply, and since the constancy of the lakes and the flow of the streams upon which the remaining 25 per cent depend is also related to the ground waters, the importance of these is really greater than the given percentage indicates. A recent investigation of 19 counties in north-central Indiana again indicates the vital relation that ground water bears to daily life. Of 54 communities in these 19 counties having public supplies, 45 use wells alone and 3 others use both streams and wells. The urban population is therefore largely dependent upon the subsurface supplies and the rural population depends almost entirely upon them. It is estimated that in Florida 750,000,000 gallons of ground waters are used daily for town and country domestic supplies, while an additional 11,500,000 gallons are used by the cities and 500,000,000 gallons for the irrigation of tobacco, citrus fruits, and vegetables. One-half of the irrigation and the greater part of the city supplies in southern California, amounting to more than 300,000,000 gallons daily, are drawn from the sands and gravels that underlie the valleys, while in central California a smaller but nevertheless important draft is made upon the same source.

These available facts, selected from widely scattered localities, indicate clearly that in addition to the almost universal dependence of the rural population upon underground waters for culinary and domestic purposes, an important and growing use is made of them for irrigation and for town supplies. It is probable that it would be safe to apply percentages but slightly less than that determined in the State of Michigan to the entire United States, and to state that nearly 75 per cent of our population depends directly upon underground waters.

RELATION TO STREAM FLOW.

The indirect dependence of mankind upon ground waters is difficult to determine. The greater part of the low-water flow of those of our streams that have no large lakes, swamps, or glaciers in their drainage basins is sustained by the slow escape from soil and rock and vegetable mulch of water that is stored there during rains and the melting of snow. An amount equivalent to the low-water flow is also contributed of course during high-water periods, so that only that part of the annual run-off of ordinary streams that is represented by the excess of flood flow over low-water flow is discharged directly from the surface, without joining the body of the percolating waters. The remainder, for a longer or shorter part of its journey from the clouds to the sea, has been stored underground and the rate of its seaward passage thereby notably checked. The greater the proportion of precipitation within a drainage basin that joins the underflow, therefore, the more regular the streams of that basin. Areas of little or no underground storage are areas of violent floods and extreme droughts, while areas with a large proportion of underground storage are areas of slight floods and large and well-sustained low-water flow. Hence as a national policy all should be done that can be done to increase underground storage.

The factors that affect it favorably or adversely are many, and too few of them are within the control of man. Hence those that he can control should be used to the best possible advantage. Among these controlling factors are the character of the precipitation, the topography, including the steepness of slopes and of stream channels, the geology—that is, the character of the rocks and the soils—and finally the vegetation.

If the precipitation is violent and is concentrated within a short period, much less opportunity is afforded for its absorption than if the rain falls gently for a longer period. Brief violent storms are characteristic of our deserts where destructive floods are followed by long-continued droughts.

The effect of the topographic character of a drainage basin is obvious. There will be relatively little run-off from a perfect plain if the rocks or soil beneath it have absorptive capacity. In a region of steep slopes and stream channels of high gradient, on the contrary, water does not stand, and a comparatively slight precipitation will be followed promptly by a notable run-off, unless other favorable factors serve to prevent it.

The influence exerted by geology is also a powerful one. The type of rock, the presence and depth or the absence of soils derived from it, and the existence of a mantle of glacial drift often make the difference between a region well supplied with ground waters and drained by streams of regular flow and a region without ground waters and with most erratic and uncontrollable streams. Loose sandstones absorb water like sponges, to yield it slowly at some lower point, perhaps in a distant drainage basin. Cavernous limestones may offer tortuous underground passages through which water escapes slowly; the loose heaps of glacial débris permit but little surface escape, so thoroughly do they absorb the water that falls upon them. The deep mantle of decayed rock that covers many of our Southern States is equally effective in this respect. Polished glacial surfaces, on the contrary, such as exist in parts of the Sierra, shed water as effectively and promptly as a roof. Dense slates, fresh and unfractured granites, or close-grained metamorphic rocks absorb little or no water and contribute practically nothing to the underground supply.

Finally, the various cover growths are of the utmost importance in modifying absorption and run-off. Trees, brush, grasses, and growing crops act in many ways to this end. Everywhere the roots, penetrating the soil and decaying there, leave little channels for the circulation of the water; on mountain slopes and rocky areas they hold loose fragments of rock by their binding root systems and prevent them from being washed away so soon. The crevices about the rock fragments which are thus held become little storage reservoirs. The trees aid in making these crevices by the prying action of their roots and by the disintegrating action of the vegetable acids that are yielded by their decay. The various growths build up a porous absorptive soil by the litter which they shed and the rock sand which becomes enmeshed in their roots, and they protect the soil which thus accumulates and prevent it being swept away. Finally, they interfere directly with run-off by the obstacles which their roots, stems, and fallen leaves and branches offer to the flow of water over the surface. In all of these functions the immediate escape of rains as sudden floods is checked and their absorption, to be slowly released later, is encouraged. It is because of the full recognition of this part that forests play in the conservation of ground waters and the regulation of run-off that engineers and geologists who have made a special study of ground-water supplies and their relation to surface waters are such earnest advocates of the conservation and extension of forest cover.

LIMITATIONS AND METHODS.

Something has been said of the wide extent of ground waters, of their enormous aggregate volume, of the direct dependence of man upon them, of their critical relation to the more obvious stream flow, and of the growing recognition of their latent value and industrial possibilities. A word should be added as to the danger of exaggerating their utility or their practical quantity in some places and the complex problems involved in their utilization.

They are ultimately dependent upon rainfall. Therefore, like surface waters, they are less abundant in arid than in humid regions, and when used there they will be less rapidly renewed. But because of the greater need more attention is paid to them in the dry than in the wet States; they are more vigorously developed there and there is more danger that they may be overdrawn.

Many gravel-filled valleys west of the Rocky Mountains contain both surface and underground waters, not enough of either alone to irrigate all of the tillable lands, but when both are used together much more valuable than when either is used alone. Often power can be developed upon surface streams and this power applied to the recovery of the earth waters that saturate the lower valley lands. This mountain water coming down to the lands from above is made to lift the underground water to the lands from below—a most admirable combination and one excellently illustrated in the case of the Santa Ana River in southern California.

A part of the water of this river is stored in a reservoir in the San Bernardino Mountains and the flow of the stream thereby regulated. After it escapes from the reservoir it is diverted through a power plant and electric power is generated. Below the first power plant it is rediverted and passed through a second power plant. Below this it is all distributed and used for municipal and irrigation purposes about Redlands and Highlands. The waters that return from the irrigation are recovered in springs and flowing wells and by pumping plants, a portion of the power developed higher up on the stream being used for the latter purpose. This recovered water is used for irrigation about San Bernardino and Riverside. A part of it reappears in the river above Riverside Narrows, where it is again taken out into a power ditch whose waters are returned to the river above Corona. A few miles below it is picked up by canals and distributed to the orange and deciduous groves about Anaheim and Santa Ana. The portion of it that returns there, by irrigation, to the ground water is once more recovered by the many pumping plants and flowing wells west of Santa Ana in the lower coastal plain.

A single drop of water in its progress from the mountains to the sea, a distance of only 100 miles, may thus be used as many as eight times for power and irrigation. This is an almost ideal use of water. The combination of power development and the recovery of underground waters to supplement the surface flow results in a minimum of waste and a maximum of economy. Development of this type is being rapidly extended now over parts of the West and will receive still further extension in the future.

But care must always be taken not to tax too severely the underground basins from which the water is drawn. They are not by any means inexhaustible. When rainfall is light, the quantity of water returned to the reservoirs each year may be small, although the quantity stored there is large. However large it may be, if more is withdrawn each year than is replaced, there will be gradual lowering of the ground-water level and ultimate disaster. Therefore, users of ground waters in arid regions must study carefully the effects of development in order to be sure that they are not prospering during the present at the expense of disaster in the future. Furthermore, in many sections where water is badly needed ground waters do not exist. Residents of such sections, urged on by their need, do not always realize this, and attempts that are hopeless from the beginning are made to procure them. Each field is a particular problem with its own solution. General rules have only a limited application.

RELATIONS TO OTHER RESOURCES AND TO CONSERVATION.

Ground waters and surface waters are, of course, intimately related. All usable ground waters were first surface waters, although perhaps only momentarily, and the greater part of them eventually become surface waters again after their journey underground is completed. It is thus that they sustain stream flow during dry periods and so are closely related to power development and to irrigation, both of which are much more successful with a sustained and regular than with an erratic run-off.

Practically all vegetable life depends upon the existence of ground water. It sustains our crops and our forests and is in turn protected by them through functions already outlined. Seventy-five per cent of our population depends directly upon it, and an important additional percentage indirectly. It is used in irrigation, in industry, in transportation, in all the many activities of life. But, being one of the resources that is constantly renewed by natural processes, we need only exercise reasonable care in our use of it to have it to draw upon perpetually. There are districts in the United States, fortunately few in number and small in area, where the ground waters are being extracted faster than they are renewed. There are other areas in which they are being contaminated and rendered useless or harmful by the careless discharge of industrial waste or sewage or brines from deep wells. There are still other areas in which, through the stripping of the natural cover growths, the annual accessions to the supply are materially reduced. These conditions must be met and remedied; then nature, through her annual rainfall, will repair the harm, as yet slight, that has been done.

FLOODS.

By M. O. Leighton,
Chief Hydrographer, United States Geological Survey.

A broad and comprehensive review of river-discharge records in the United States indicates unmistakably that floods are increasing. It is true that the opposite tendency may be shown on some rivers, while the records on others may indicate little or no change; but, taken as a whole, the rivers that reveal more intense flood tendencies so thoroughly dominate the situation that the conclusion above expressed must be inevitable.

It will be well to consider at the outset just what index may be used to determine the trend of flood tendencies. It is common in inquiries of this character to select and compare the highest stages attained in the several years of record, and because, perchance, higher floods may be shown in early years, many really competent persons have believed themselves forced to the conclusion that there is no increase in flood tendency. The actual height attained by the maximum flood each year is, however, a matter of small consequence in such considerations. A little reflection will show how this must be true. The precipitation, which is the ultimate cause of floods, takes three courses, only two of which are really important in the present discussion, namely, the course along the surface of the ground directly into watercourses, and that into the ground by percolation, with subsequent discharge into the rivers by seepage. In general terms it may be stated that the water which causes floods is that proportion of the precipitation which the earth does not absorb and which, therefore, must flow along the earth's surface. Now it is apparent that when precipitation becomes so intense and long continued that it practically saturates the ground the rain that falls thereafter must take the direct route and floods must necessarily arise. Therefore the height of great floods is fixed primarily by the intensity of precipitation and, as the amount of rain varies from year to year, now bountiful and again scanty in what seem to be fairly uniform cycles of years, the observation of an especially high flood during an early year compared with that of a much lower one during a recent year can give no index to flood tendency in any river. The real index is of more fundamental origin than the mere occurrence of high floods.

When the question "Are floods increasing?" is asked, the considerations involved are not those of height but those of duration and frequency. In other words, the question means, Are floods of more frequent occurrence and are there more days of flood than formerly? Reverting for the moment to the discussion in the foregoing paragraphs, it is plain that floods will occur more frequently in response to a given rate of precipitation, if there are in the drainage area influences that either inhibit or prevent the ready absorption of the rain by the ground, than they would if absorption were ideal. Such ideal condition assures complete absorption of all precipitation. A rain of a given depth in a unit's time—say 2 inches in one day—would surely produce a flood in a drainage area which was nonabsorbent. On the other hand, the same amount of rain would not change the river stage if the conditions enhancing absorption on the drainage area were ideal. Between these two extremes there are wide and varying conditions which tend to increase or to diminish the resultant floods from a given rainfall. In other words, the question "Are floods increasing?" means, essentially, Are the conditions of the surface of the ground in the river basins so changing that they render the ground less absorbent? If this be the case, it is clear that a much larger proportion of the precipitation would run directly off into the rivers than that which was so conducted at an earlier period.

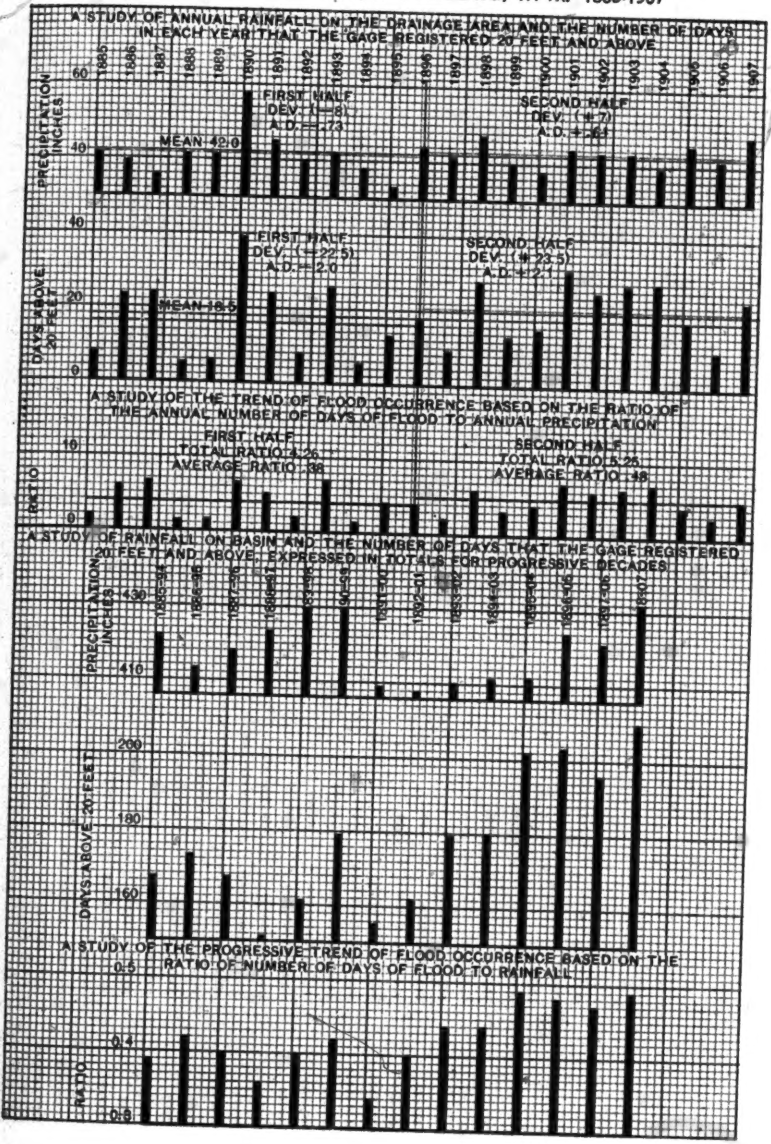
There are five classes of agencies or conditions affecting the flow of streams. The first is climate, under which are comprised rainfall, evaporation, temperature, wind, and humidity. Although these are exceedingly variable from day to day and from season to season, the observations that have been recorded indicate that a period of years embraces all conditions, so that the mean of them may be considered fairly constant. There is very little evidence, except in special areas, that reveals any progressive and permanent change in climatic conditions. The second agency is topography, and the third geology, both of which may, for present purposes, be considered absolutely stable. The fourth is surface vegetation, which includes forest cover and cultivated land. This is subject to progressive change, according to the demands, conveniences, and usages of society. The fifth consists of artificial agencies, such as storage, reservoirs, and drainage, which produce rapid and marked effects on river discharge.

Therefore, the consideration of river discharge and especially of floods involves the appraisal of the effects of climate, vegetation, and artificial agencies. The other two agencies, being constant, may be left out of consideration. It is necessary to take account of these conditions in connection with all studies of progressive flood trend. This emphasizes the futility of many studies that have heretofore been made, in which not only have the extreme flood heights been the basis of determination, but there has been a total lack of consideration of climatic conditions, especially that of rainfall. A river, for example, may show a progressive decrease in flood frequency during a period of years. If that were taken alone it would indicate a decreasing flood trend; whereas, if the rainfall be compared progressively in the same manner, it might readily be shown that the flood trend was increasing rather than diminishing, because the precipitation was decreasing faster than the flood frequency.

The above considerations have been kept in mind in the study of flood frequency here presented. The accompanying diagrams, Nos. 1 to 8, inclusive, are the result of appropriate studies made of flood occurrence on rivers on which gages have been maintained for a long period, the longest, in fact, of which there are available and useful records in this country. Examination shows conclusively the increasing trend of flood occurrence and the cause thereof comes now properly into question.

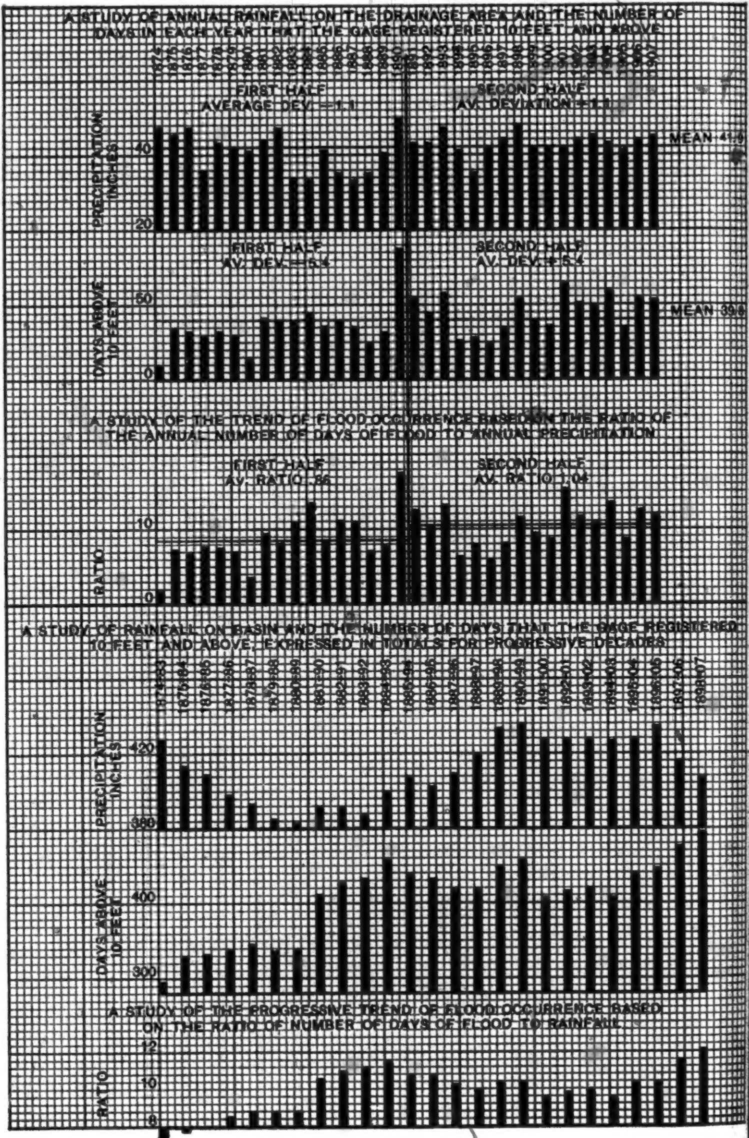
No. 1.

FLOODS ON OHIO RIVER AT WHEELING, W. VA. 1885-1907



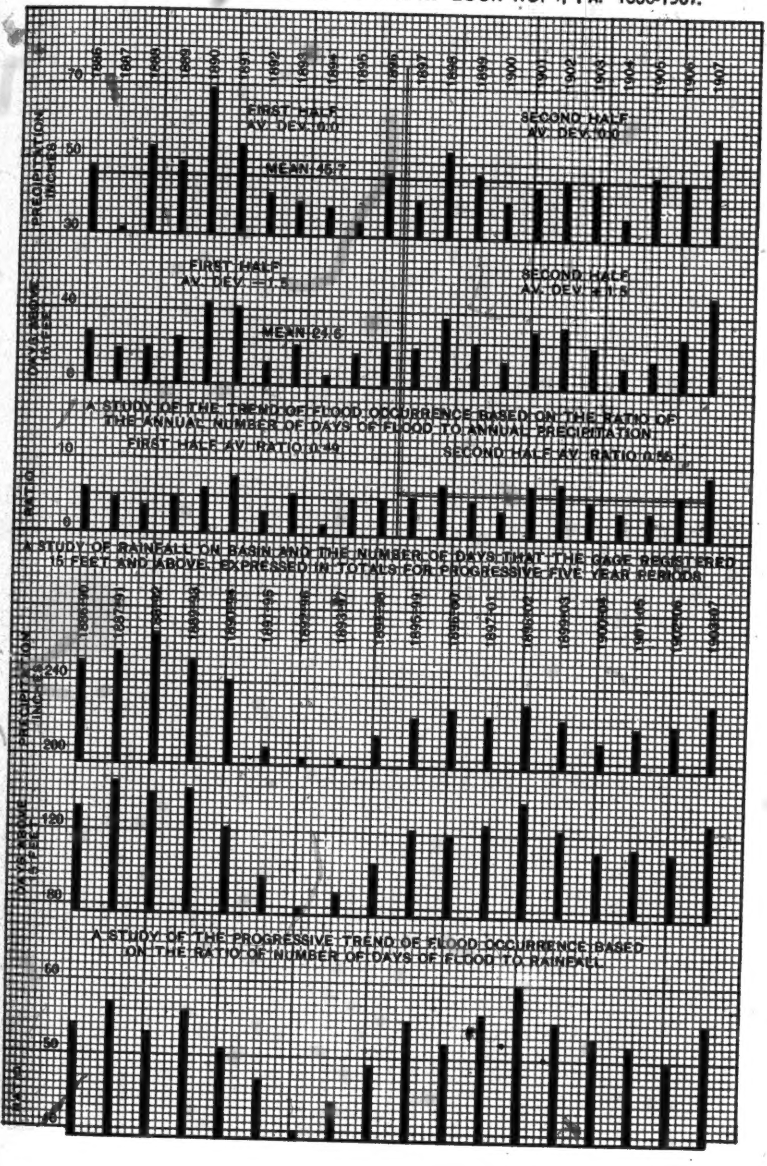
No. 2.

FLOODS ON ALLEGHENY RIVER AT FREEPORT, PA. 1874-1907.



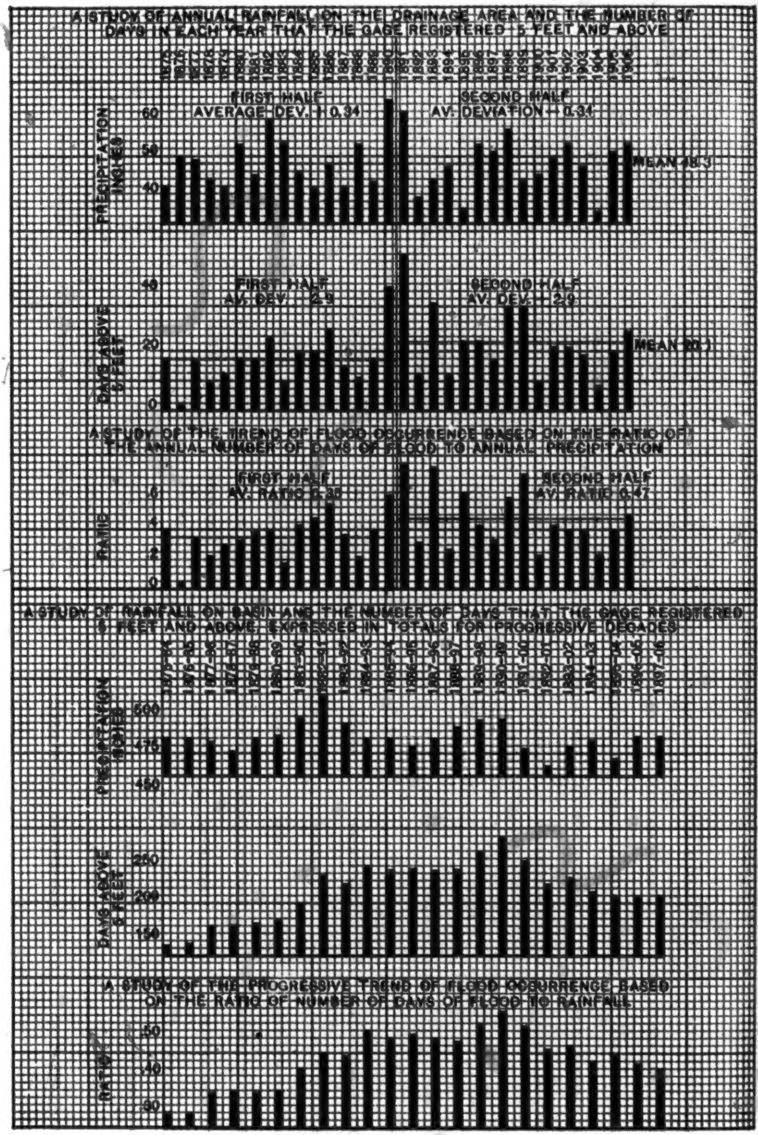
No. 3.

FLOODS ON MONONGAHELA RIVER AT LOCK NO. 4, PA. 1886-1907.



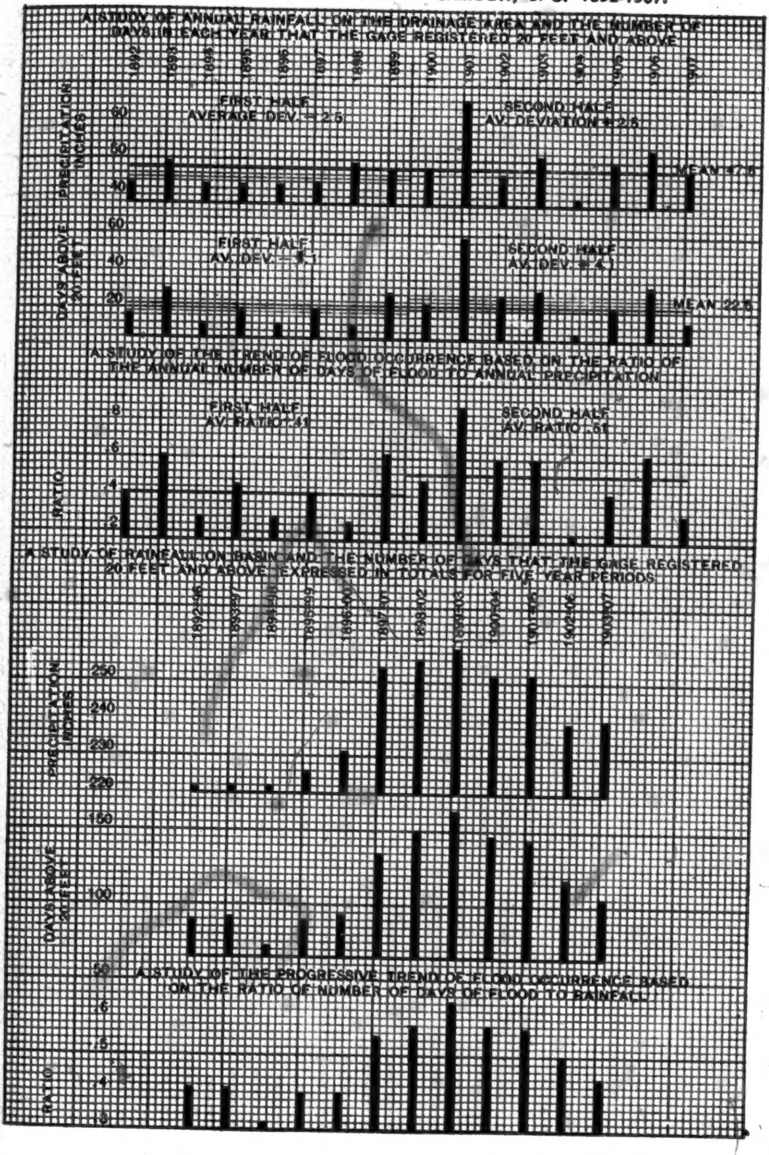
No. 4.

FLOODS ON YOUGHIQGHENY RIVER AT CONFLUENCE, PA. 1875–1906.



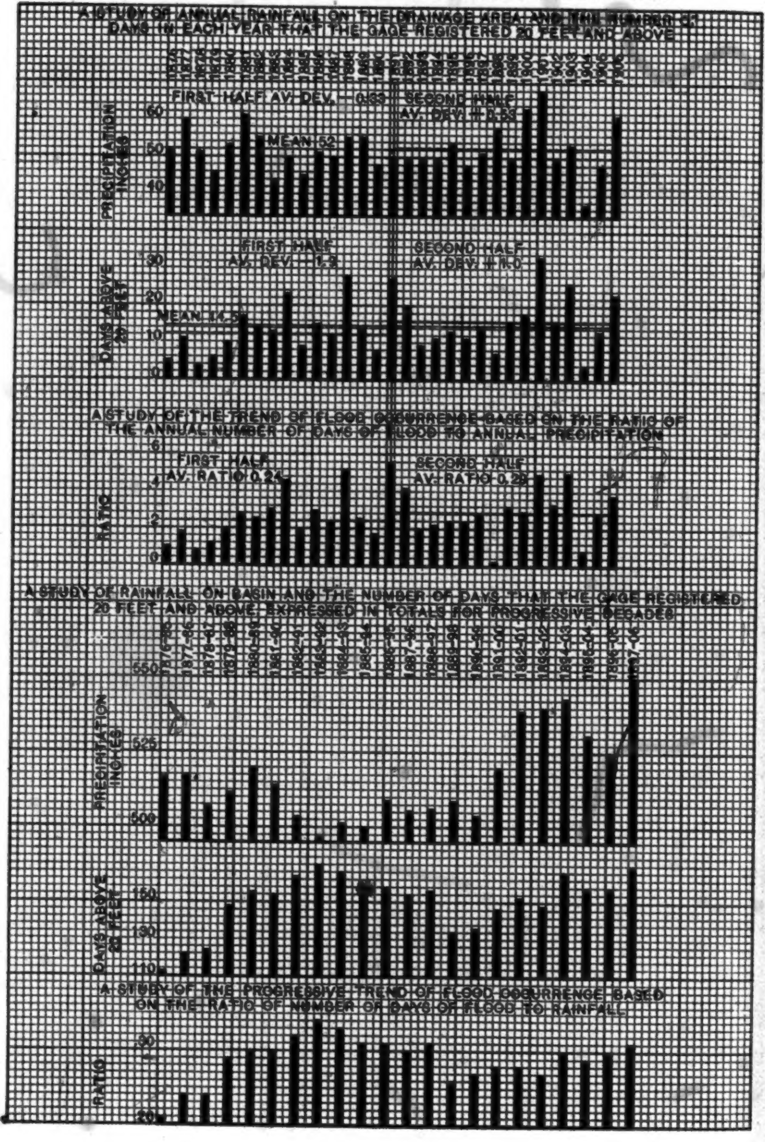
No. 5.

FLOODS ON WATEREE RIVER AT CAMDEN, S. C. 1892-1907.



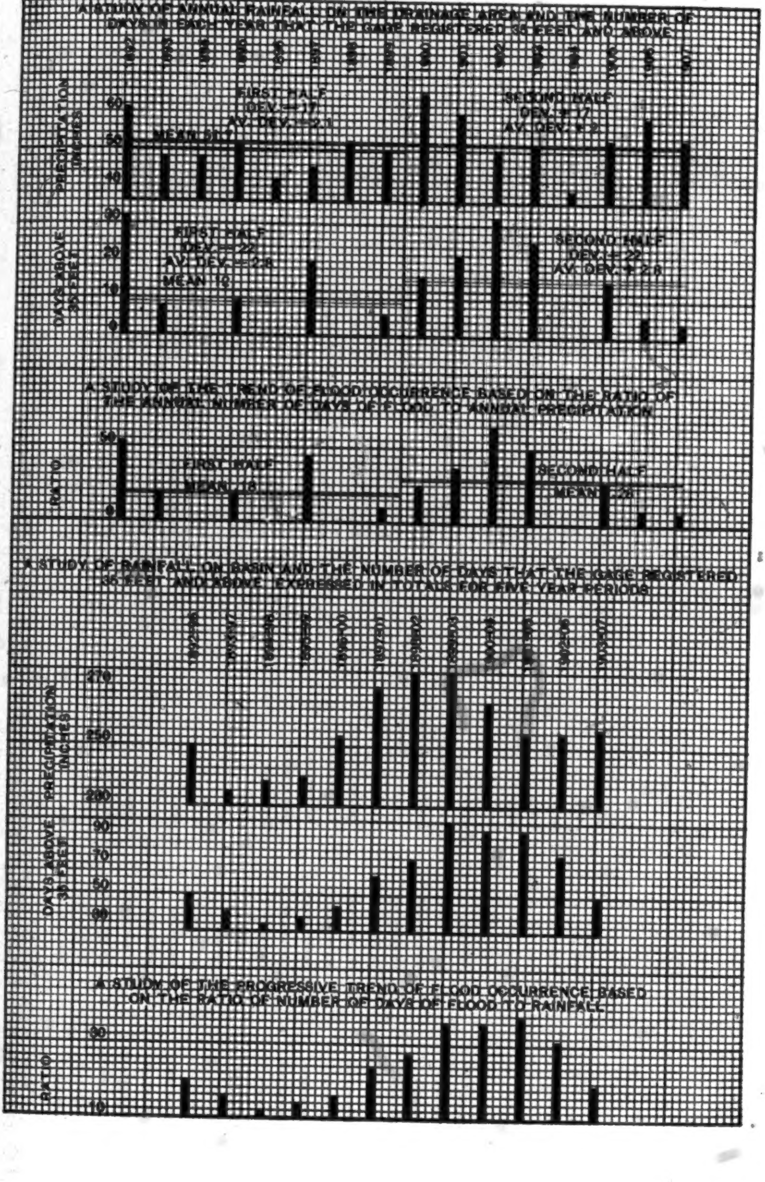
No. 6.

FLOODS ON SAVANNAH RIVER AT AUGUSTA, GA. 1876–1906.



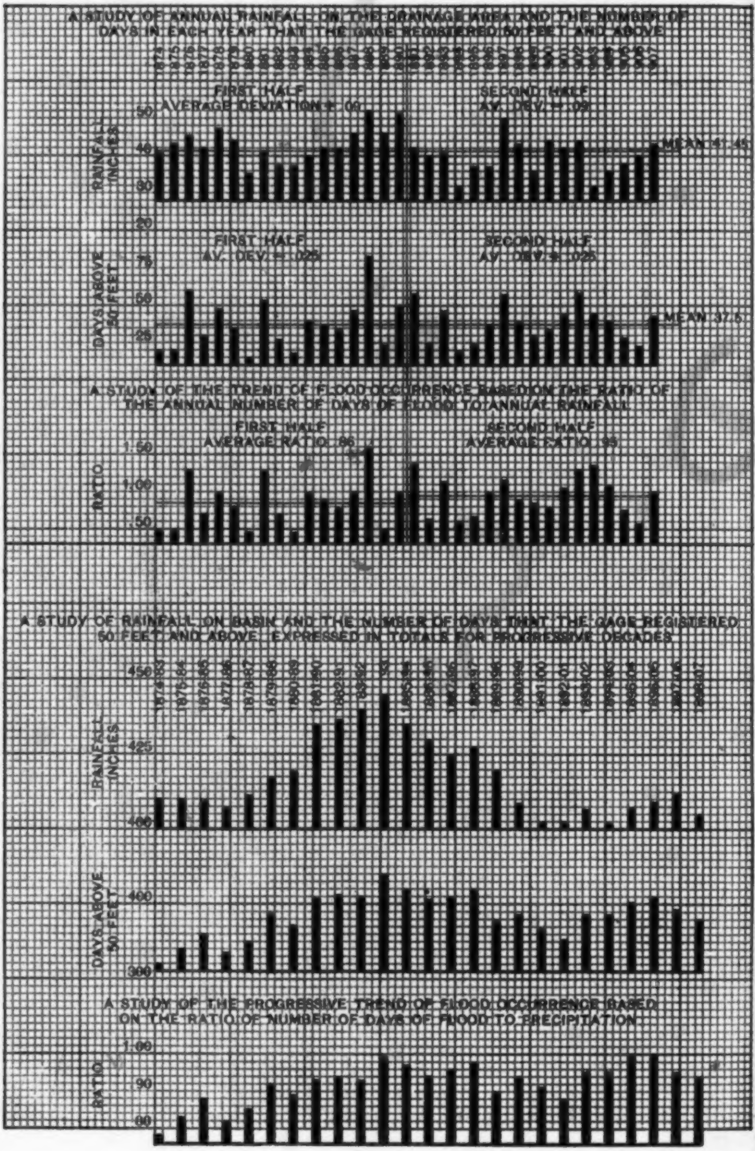
No. 7.

FLOODS ON ALABAMA RIVER AT SELMA, ALA. 1892-1907.



No. 8.

FLOODS ON CONNECTICUT RIVER AT HOLYOKE, MASS. 1874-1907.



A STUDY OF ANNUAL RAINFALL ON THE DRAINAGE AREA AND THE NUMBER OF DAYS IN EACH YEAR THAT THE GAGE REGISTERED 50 FEET AND ABOVE

A STUDY OF THE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF THE ANNUAL NUMBER OF DAYS OF FLOOD TO ANNUAL RAINFALL

A STUDY OF RAINFALL ON BASIN AND THE NUMBER OF DAYS THAT THE GAGE REGISTERED 50 FEET AND ABOVE EXPRESSED IN TOTALS FOR PROGRESSIVE DECADES

A STUDY OF THE PROGRESSIVE TREND OF FLOOD OCCURRENCE BASED ON THE RATIO OF NUMBER OF DAYS OF FLOOD TO PRECIPITATION

1874
1875
1876
1877
1878
1907
FIRST HALF
AVERAGE DEVIATION ± .09
SECOND HALF
AV. DEV. ± .09
RAINFALL INCHES
50
40
30
20
MEAN 41.45
FIRST HALF
AV. DEV. ± .025
SECOND HALF
AV. DEV. ± .025
DAYS ABOVE 50 FEET
75
50
25
MEAN 37.5
FIRST HALF
AVERAGE RATIO .86
SECOND HALF
AVERAGE RATIO .95
RATIO
1.50
1.00
.50
1874-83
1875-84
1876-85
1877-86
1878-87
1879-88
1880-89
1881-90
1898-07
RAINFALL INCHES
450
425
400
DAYS ABOVE 50 FEET
400
300
RATIO
1.00
.90
.80

As already stated, the rainfall, which is by far the most important of the climatic conditions, has been accounted for in these diagrams, and we have, therefore, remaining only the condition of the ground surfaces in the drainage areas and artificial agencies. For each of these rivers artificial agencies may be eliminated. Our general knowledge of conditions on the drainage areas gives assurance that there has been no reservoir installation of extent sufficient to modify in the slightest degree the normal conditions of flood discharge. This is also true with respect to artificial drainage.

Therefore we come down to the condition of the land surface, or, as above expressed, conditions of vegetation. We are aware that on all of these drainage areas there has been progressive cutting of timber and building of roads. The latter improvements, however, have not been of sufficient extent to modify in any appreciable degree the discharge. A computation of the actual road areas, including the paved streets, etc., will show conclusively that, in comparison with the total area under consideration, they are insignificant. The conditions of cultivated fields undoubtedly have a marked influence in modifying the rate of river discharge, and it is certain that some of the effects in these areas are due to this cause. The cultivation of fields has, however, improved markedly in recent years. The farmer has learned to a considerable degree that it is more profitable for him to cultivate his inclined fields by contour or terrace cultivation, and a cursory view of the areas represented in the accompanying diagrams will show that to a very large extent improved methods of cultivation have been put into effect.

Altogether, when the physical conditions on the drainage areas are summed up, the one great change that has been produced in the vegetative conditions is the reduction of forest area. On some of these drainage areas it has occurred by slow progression and on others more rapidly. It is certain that in some areas this forest cutting has caused barren conditions, because the land was of such a character that, after it was relieved of forest protection, it eroded easily and its productive portions were quickly swept into watercourses.

Summarily, therefore, it may be stated with confidence that the increase in flood tendency shown so unmistakably is due in by far the largest measure to the denudation of forest areas.

Diagrams 1 to 4, inclusive, are expressions of progressive changes in flood occurrence during the series of years indicated thereon. They are all drafted on a uniform basis, the first expression in each case being a record of the annual precipitation in inches; the second gives the number of days in each year that the gage at the point designated registered above a certain stage; the third is a combination of the first two and gives the relation of the number of days of flood to the precipitation. Thus, there is given in one expression the actual trend of flood occurrence in terms of precipitation. This form of expression eliminates one variable in the conditions governing flood occurrence, and the only remaining ones to be considered are vegetation and artificial agencies, as discussed in previous paragraphs.

The second series of diagrams on each sheet gives the same relations except that the amounts are united into progressive decades, or in one case into progressive five-year periods. This form of expression serves to neutralize the variability that occurs in the successive years and gives to the whole diagram a progressive trend which is more comprehensive and more easily interpreted than the statement of actual amounts. Thus, in sheet No. 1, the first progressive period covers the interval from 1885 to 1894, the second that from 1886 to 1895, and so on, each period representing ten years, and the total amount of rainfall and the total number of days of flood for each decade is expressed, rather than the average amount of these quantities.

In interpreting diagrams of this kind it should be emphasized that the amounts actually shown are not significant, save as they indicate the relative trend of the successive decades. In other words, the diagrams indicate direction, and should be so interpreted.

The data given on the above-mentioned sheets relate to the upper Ohio drainage area, and they show the relation of flood occurrence on the three principal tributaries thereof—the Allegheny, Youghiogheny, and Monongahela rivers—to flood occurrence on the Ohio at Wheeling. It will be seen that in each case there has been a marked increase in the number of days of floods, and the four diagrams can be consistently compared. At Wheeling during the period 1885 to 1907, inclusive, the ratio of flood occurrence to annual precipitation increased from 0.38 in the first half of the period to 0.48 in the second half, and this relation is shown more distinctly in the similar expression with the amounts given in totals for progressive decades. The gage records on the Allegheny at Freeport, Pa., show an increase in this ratio from 0.86 in the first half to 1.04 in the second half of the period 1874 to 1907, inclusive. The Monongahela record shows an increase of ratio during the period 1886 to 1907, inclusive, from 0.49 in the first half to 0.55 in the second half, while a still greater divergence is noted on the Youghiogheny, the ratio for the period 1875 to 1906, inclusive, increasing from 0.35 in the first half to 0.47 in the second half.

Altogether, these diagrams are extremely significant in showing the progressive increase in flood occurrence on a drainage area the deforestation of which has been constant and rapid for the past thirty years. It began first on the Allegheny and the results are apparent in the diagrams. Subsequently, timber cutting began on the Monongahela and Youghiogheny areas and is occurring at the present time.

Similar results are shown on sheets Nos. 5 to 7, inclusive, which give the same data for Wateree River above Camden, S. C., the Savannah above Augusta, Ga., and the Alabama above Selma, Ala.

Sheet No. 8 is a record of flood duration on Connecticut River at Holyoke, Mass. This river basin has been subject to continuous deforestation for a long period. Recent testimony shows that for the last twenty years from 50,000,000 to 80,000,000 feet B. M. of timber have been released over the dam at Turners Falls annually. Records of private logging are not available, but it is known that the deforestation of the drainage area commenced some time previous to this period.

There is one point of objection that may reasonably be taken to the diagrams above discussed. It is that they draw comparison between annual precipitation and the number of days of flood. A better comparison would be one between the number and depth of flood-producing rains and the number of flood days. Such a comparison has been made on the Tennessee basin above Chattanooga. No other basins are here dealt with in this way because of the enormous amount of labor involved.

In addition to proving beyond controversy the increase in floods due to deforestation, the record is of interest because it shows how futile and misleading is the attempt to derive conclusions from flood records without taking into account records of precipitation. Inspection of the Chattanooga flood record shows a decided decrease in the number and duration of floods during the period of record. If this were taken alone, it would controvert the forest-control idea. A comparison of the precipitation records on the drainage area, however, assures us that the rainfall has decreased, even to a greater relative extent than the floods. The final result is that the flood tendencies have increased.

The results for the Tennessee basin cover 24 years, from 1884 to 1907, inclusive. Although the records of gage height extend further back than the earlier date, the number of rainfall stations maintained on the basin previous thereto is not sufficient to render safe any conclusions with reference to precipitation. It is appreciated that a given depth of rainfall precipitated during the winter months will generally produce a greater run-off than the same depth would produce in August or September. Therefore an effort has been made to eliminate this source of error. Summing up the flood-producing rains for the 24-year period it is found that the total is 335, of which 313 occurred from December to May, inclusive, and the remaining 22 during the other portion of the year. It is apparent that the number of such rains from June to November is not sufficient to afford a basis of comparison. Therefore only the December to May floods will be considered. In making this comparison the ideal condition would be to compare the rainfalls and floods during identical conditions of climate, but such a refinement is impossible. On the other hand, the multiplication of data afforded by the large number of flood-producing storms in the December to May periods warrants the conclusion that the varying climatic conditions in this period are compensated, and the final conclusions drawn from the result must be worthy of confidence. On dividing the period covered by these 313 floods equally, two consecutive 12-year periods are afforded, which give a basis of comparison. The floods in the later period, resulting from a given depth of storm precipitation, are clearly shown to be more severe than in the earlier period. The method of presentation further makes it possible to compute the increase in flood tendency due to deforestation in the Tennessee.

The relation between storms and floods in the Tennessee basin during the periods December–May, inclusive, 1884–1895 and 1896–1907.

Period.	Storms in inches precipitated.											
	1 to 1.5.		1.5 to 2.		2 to 2.5.		2.5 to 3.		3 to 3.5.		3.5 to 4.	
	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.
1884–1895	7	5	12	6	6	15	5	9	5	13	6	30
1896–1907	8	3	11	10	9	23	11	30	4	13	1	6

Period.	Storms in inches precipitated.											
	4 to 4.5.		4.5 to 5.		5 to 5.5.		6 to 6.5.		7 to 7.5.		8 to 8.5.	
	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.	Storms.	Days of flood.
1884–1895	1	6	2	17	2	18	......	......	2	28	......	......
1896–1907	1	8	3	20	......	......	1	11	......	......	1	17

If we now divide the number of flood days by the number of storms, the result will be the number of days per storm. Applying this to each of the series in the above table, the following result is reached:

Days of flood per storm.

Period.	Storms in inches precipitated.							
	1 to 1.5.	1.5 to 2.	2 to 2.5.	2.5 to 3.	3 to 3.5.	3.5 to 4.	4 to 4.5.	4.5 to 5.
1884–1895	0.7	0.5	2.5	1.8	2.6	5	6	8.1
1896–1907	.4	.9	2.6	2.7	3.2	6	8	6.7
Percentage increase	−43	80	4	50	22	20	33	−17

The algebraic sum of the above percentages is 149.00 and the average is 18.75, which sums up the effect of deforestation on run-off from 1884 to 1907, inclusive.

FLOOD DAMAGES.

A complete census of flood damages for any year or series of years has never been attempted. Therefore, it will be impossible to present any figures for which precision may be claimed. The damages for particular floods in certain areas have from time to time and for one or another purpose been assembled and, in a few places, examinations have been made with great care by commissions and boards especially qualified for such work. The results of such examinations may be taken to form a basis for an estimate; but, for the present purpose, a better basis has been made available. During the present year the Geological Survey has made inquiry of all the railroads in the United States concerning flood losses during the period January 1, 1900, to August, 1908. The railroads were selected for this purpose because it is well known that they are, by reason of their location and extent, subject to far greater physical damage than any other single interest, and it was believed that from the figures so procured a fairly representative basis of estimate might be obtained. From previous studies of this matter it appeared that the railroad losses resulting from floods amount to about 10 per cent of the total physical loss arising therefrom, excluding, of course, the largest single item of loss, which is the depreciation of realty values arising from flood menace. The figures here presented will therefore exclude all consideration of this kind of loss.

The proportion of 10 per cent was arrived at from three points of view:

First. It has been the observation of the writer that, as a rule, the reported losses to railroads from floods have amounted to about this proportion.

Second. The actual investigations of flood losses, made by appraisal boards, and individual property returns covering fairly wide areas have approximated this proportion. Undoubtedly the most complete and comprehensive investigation of this kind was carried on by the northern New Jersey flood commission in 1903, after the great flood that arose in October of that year along Passaic River. The region comprehended in this investigation may be considered a typical one. It comprised the usual proportion of farm lands, city areas, highway bridges, railroad property, etc., and the proportion of railroad loss there was almost exactly 10 per cent of the total.

Third. One-tenth of the wealth of the United States consists of railroad property. This proportion was therefore used in the following estimates.

During each of the periods above named the returns from the railroads involved a varying percentage of the total mileage of the country. The mileage involved in each yearly estimate has been expressed as a percentage of the total mileage for that year, as given in the reports of the Interstate Commerce Commission. The several amounts were increased from the percentage that they represented to 100 per cent, to cover the entire mileage of the country. Inspection of the returns showed that this was a fair and reasonable method, because the reports were well distributed and represented a true proportion of that which might be expected to be the damage on the total mileage. This figure was then considered as 10 per cent of the total damage for the whole country and increased accordingly. The results are given in the following table:

Year.	Damage reported.	Percentage of total mileage reported.	Total railroad damage.	Estimated total damage.
1900				
1901	$666,253	14.6	$4,567,500	$45,675,000
1902	958,740	21.1	4,543,800	45,438,000
1903	1,225,468	22.2	5,520,100	55,201,000
1904	2,654,192	27.3	9,722,000	97,220,000
1905	2,476,724	31.3	7,884,100	78,841,000
1906	3,286,324	33.3	9,858,972	98,589,720
1907	2,727,511	37.3	7,312,400	73,124,000
1908	4,623,106	39.1	11,823,800	118,238,000
	6,517,577	27.4	23,786,000	237,860,000

STORAGE OF FLOOD WATERS.

In the northeastern portion of the country there has been a large installation of reservoirs and a consequent saving of enormous amounts of flood water. The numerous lakes in that part of the United States, irrespective of those that have been developed artificially, have a beneficial effect. It is probable that 10 per cent of the flood waters that originate in New York and New England are saved by storage in artificial reservoirs, lakes, and ponds. In Minnesota, at the head of upper Mississippi River, practically the entire flood drainage from an extensive area is conserved. In the arid West there has been an extensive installation of reservoirs, some of which conserve practically all the flood waters on their respective basins. Considering the country as a whole, however, it is doubtful if more than 1 per cent of the flood water is saved.

The storage of floods is effected by forests and similar surface vegetation and by artificial reservoirs. The amount stored by forests is and probably will for a long time to come be indeterminate, since the forest is merely an agent in assisting the ground to absorb the water. The storage is therefore essentially ground storage and the ability of the forest to enhance this is dependent absolutely on the character of the soil beneath the forest. Therefore, to fully answer the question, "To what extent could flood waters be stored by forests?" it would be necessary to consider minutely the absorption properties of the various kinds of land surface in the United States. It will be possible at some future time to give an approximate and exceedingly useful reply to this question; but before that time arrives we must have more long-term gage records on our rivers. The diagrams presented with this paper (sheets Nos. 1 to 8, inclusive) constitute as useful records as there are extant in the country, and a short consideration of them will plainly reveal the fact that, while they are exceedingly useful in indicating the trend of flood duration and frequency, they do not yet yield sufficient information to give even the widest approximation of the amount of water or the proportion of run-off that can be conserved.

The question is therefore one for the future, and our stream investigations should be carried on with this as one of the purposes in view.

The extent to which flood waters could be stored by reservoirs depends on the available reservoir capacity in the several river basins. As a rule, the more diversified the character of these basins, especially in contour, the greater facilities they afford for reservoir storage.

There is a great portion of the Mississippi Valley in which floods are not subject to correction under the reservoir plan. This is also true of certain coastal-plain streams like the Brazos and Colorado. It is probable that the streams draining one-third of the area of the United States must forever be subject to floods, and the only treatment that now appears feasible for these streams is the construction of levee systems. For the remaining two-thirds of the United States, investigations so far made indicate that from 55 to 60 per cent of the flood waters can be saved by the utilization of maximum storage capacity. Although the cost of such construction would be enormous in the aggregate, it is apparent that the saving that would accrue from relief from flood damages alone would soon return the entire investment. A glance at the estimated flood damages in the United States, page 109, shows the possibilities. In this connection it should be stated that in by far the larger proportion of the basins a saving of 55 to 60 per cent of the flood waters would insure practically entire relief from flood damages. It is not necessary to prevent floods absolutely; or, in other words, it is not necessary to secure uniformity of flow in any river in order to secure relief from flood damages. The construction of the reservoirs necessary to prevent floods would, under proper management, involve an increase in the water-power possibilities of the United States equal to about 60,000,000 horsepower. In the arid West the construction of reservoirs for flood prevention would provide water sufficient for the reclamation of many million acres of now worthless land. All of this, together with the assistance that such reservoirs would lend to navigation, constitutes the saving that would accrue from their construction. We are unable at the present time even to approximate the total figure, and therefore it must be summed up in the term "vast."

RELATION OF SURFACE CONDITIONS TO STREAM FLOW.

By WM. L. HALL and HU MAXWELL.
U. S. Forest Service.

Popular opinion for years has been that floods are increasing in frequency and duration in many rivers of the United States. Until within a year, however, there had been no careful examination of records to see whether or not the popular opinion is based upon fact. The scientific bureaus of the Government which are directly interested in the matter had assumed that records had not been kept long enough on any river to show a change in the conditions of flow. As late as September, 1908, Col. H. M. Chittenden, of the Engineer Corps of the Army, in a paper presented before the American Society of Civil Engineers, said:

> The constantly reiterated statement that floods are increasing in frequency and intensity, as compared with former times, has nothing to support it. There are, it is true, periods when floods are more frequent than at others, and hasty conclusions are always drawn at such times, but taking the records year after year for considerable periods no change worth considering is discoverable.

About a year ago it was thought worth while to look into the records to see whether any changes were discernible. The results were surprising. It was found that in many of the streams which take their rise in the Appalachian Mountains there has been a steady increase in the number and duration of floods during the past twenty or thirty years.

Following this discovery, a very general study was made of the change which has come about in the flow of a number of important rivers during the time for which records have been kept. Both the Geological Survey and the Forest Service have presented data on this subject during the year, and the results of both warrant the statement that unmistakably floods are steadily on the increase in some of our most important rivers.[a] Particularly is this true of the rivers which rise in the eastern mountains. The increases seem to be greater on those watersheds where the condition of the surface has been the most changed. They are greatest in such streams as the Ohio, Cumberland, Wateree, and Santee, where the most forest has been destroyed, and least on the streams where forest conditions have been least changed.

It is true that in certain rivers an opposite tendency is to be seen. Floods have decreased and low waters have markedly improved. But a full inquiry into the conditions on these rivers also, as will be shown, seems to prove the rule that there is the closest kind of relationship between the surface conditions of a watershed and the flow of water through the stream which drains it.

The following table gives records regarding the flow of 10 important rivers of the United States on which careful records have been kept for periods ranging from sixteen to thirty-four years:

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[a] Floods in the United States, by M. O. Leighton, Chief Hydrographer, U. S. Geological Survey. Paper prepared for National Conservation Commission.

Flood and low-water records for 10 important rivers.

CLASS I.—FLOODS INCREASED.

Name of stream.	Point of measurement.	Area of basin.	High-water stages taken in this table.	Low-water stages taken in this table.	First and second periods of record.		High-water data.						Low-water data.						Precipitation.		
					Years.	Duration.	Number of floods.	Days of floods.	Average times per year of floods.	Average days per year of floods.	Times of last period compared with first.	Days of last period compared with first.	Number of low stages.	Days of low stages.	Average times per year of low stages.	Average days per year of low stages.	Times of last period compared with first.	Days of last period compared with first.	Number of stations.	Mean (inches).	Mean annual increase or decrease (inches).
		Sq. mi.	*Ft.*	*Ft.*		*Yrs.*					*Per ct.*	*Per ct.*					*Per ct.*	*Per ct.*			
Potomac	Harpers Ferry, Va.	9,363	12	3	1890-1898	9	19	33	2.11	3.55	a 36.80	a 72.70	54	1,351	6.00	150.00	a 40.7	a 25.3	5	36.81	+.13
					1899-1907	9	26	57	2.77	6.33			76	1,693	8.44	188.00			5	37.97	
Monongahela	Lock 4, Pennsylvania	5,430	20	7	1886-1896	11	30	55	2.73	5.09	a 73.00	a 82.00	66	912	6.00	83.00	a 36.33	a 7.33	6	42.25	—.08
					1897-1907	11	52	100	4.73	9.09			90	979	8.17	89.00			6	41.35	
Ohio	Wheeling, W. Va.	23,820	22	5	1882-1894	13	46	143	3.54	11.00	a 28.25	a 31.50	79	1,333	6.08	112.50	a 39.00	a 20.75	11	41.74	—.14
					1895-1907	13	59	188	4.54	14.40			110	1,609	8.46	123.70			11	39.90	
Cumberland	Burnside, Ky.	3,739	25	3	1890-1898	9	32	89	3.55	9.90	a 34.40	a 14.60	61	1,261	6.77	138.00	a 6.50	a 27.00	3	46.27	—.54
					1899-1907	9	43	102	4.77	11.33			65	1,576	7.17	175.00			3	41.42	
Wateree	Camden, S. C.	5,135	20	6	1892-1899	8	46	147	5.75	18.37	a 35.00	a 22.00	115	1,164	14.37	145.50	b 44.30	b 56.40	3	45.46	+.25
					1900-1907	8	70	187	7.75	23.50			64	508	8.00	63.50			3	47.48	
Savannah	Augusta, Ga.	7,300	20	6	1890-1898	9	47	116	5.22	12.77	a 23.40	a 46.50	70	566	7.70	63.00	b 41.00	b 48.00	3	48.12	—.17
					1899-1907	9	58	170	6.44	17.77			41	292	3.56	32.00			3	46.58	
Tennessee	Chattanooga, Tenn.	21,418	24	2	1874-1890	17	32	173	1.88	10.18	a 3.13	b 20.80	71	902	4.17	53.00	b 22.53	a 8.86	5	53.17	—.37
					1891-1907	17	33	137	1.94	8.06			55	962	3.24	57.70			5	46.83	
Allegheny	Freeport, Pa.	9,220	16	2	1874-1890	17	39	92	2.29	5.41	a 35.90	a 42.40	99	1,747	5.82	102.70	b 8.10	a 35.00	3	41.65	—.32
					1891-1907	17	53	131	3.12	7.70			91	1,136	5.35	66.80			3	36.17	

CLASS II.—FLOODS DECREASED.

Name of stream.	Point of measurement.	Area of basin.	High-water stages taken in this table.	Low-water stages taken in this table.	Years.	Duration.	Number of floods.	Days of floods.	Average times per year of floods.	Average days per year of floods.	Times of last period compared with first.	Days of last period compared with first.	Number of low stages.	Days of low stages.	Average times per year of low stages.	Average days per year of low stages.	Times of last period compared with first.	Days of last period compared with first.	Number of stations.	Mean (inches).	Mean annual increase or decrease (inches).
Wabash	Mount Carmel, Ill.	26,300	15	3	1890-1898	9	21	351	2.33	39.00	b 9.50	b 20.50	38	1,365	4.22	152.00	b 15.75	b 15.00	5	39.54	—.40
					1899-1907	9	19	279	2.11	31.00			44	1,160	4.93	129.00			5	35.99	
Red	Arthur City, Tex.	40,200	20	4	1892-1899	8	19	87	2.37	10.87	b 16.00	b 30.00	49	826	6.12	103.25	b 83.60	b 74.80	5	31.80	—.24
					1900-1907	8	16	60	2.00	7.50			8	208	1.00	26.00			5	29.86	

a Increase.

b Decrease.

THE TENDENCY IS TOWARD INCREASED FLOODS.

If the period during which the records have been taken on each of these streams be divided into two equal parts and a comparison be made of flood conditions for those parts, we find that 8 of the 10 rivers show greater floods in the last half than in the first half. The 8 rivers which show increased floods are the Potomac, at Harpers Ferry, W. Va.; the Monongahela, at Lock 4, Pennsylvania; the Ohio, at Wheeling, W. Va.; the Cumberland, at Burnside, Ky.; the Wateree, at Camden, S. C.; the Savannah, at Augusta, Ga.; the Allegheny, at Freeport, Pa.; and the Tennessee, at Chattanooga, Tenn. All of these streams, it will be noted, have their source waters in the Appalachian Mountains.

On the Potomac River, for which measurements are given for eighteen years, the number of floods during the first half of the period was 19; during the second half, 26; while the number of days of flood in the first half was 33, and in the second half, 57.

On the Monongahela River measurements are given for twenty-two years. During the first half of the period there were 30 floods; during the second half, 52. The number of days of flood during the first half of the period was 55; during the second half, 100.

On the Ohio River measurements are given for twenty-six years. During the first half of the period there were 46 floods; during the second half, 59. The number of days of flood during the first half was 143; during the second half, 188.

On the Cumberland River measurements were given for eighteen years. During the first half of the period there were 32 floods; during the second half, 43. The number of days of flood during the first half was 89; during the second half, 102.

On the Wateree River measurements have gone on for sixteen years. In the first half of the period the number of floods was 46; in the second half, 70. The number of days of flood in the first half of the period was 147; in the last half, 187.

On the Savannah River measurements have continued for eighteen years. During the first half of the period the number of floods was 47; during the second half, 58. The number of days of flood during the first period was 116; during the second half, 170.

On the Allegheny River measurements are given for thirty-four years. During the first half of the period there were 39 floods; during the second half, 53. The number of days of flood during the first half was 92; during the second half, 131.

On the Tennessee River measurements have been taken for thirty-four years. During the first half of the period there were 32 floods; during the second half, 33. The number of days of flood during the first half was 173; during the second half (in this case there was a falling-off), 137.

Mr. M. O. Leighton, chief hydrographer of the United States Geological Survey, has during the past year made an elaborate study of the floods in the Tennessee River.[a] In this study Mr. Leighton has isolated so far as possible the days of rain storm of sufficient magnitude to produce floods, and on this basis has made a comparison of the floods of the two halves of the period. Although the number of days of flood was less during the last half of the period than during the first half, Mr. Leighton shows that the precipitation decreased in an even greater degree. The results of this close analysis show that the diminution of the precipitation has been more than sufficient to account for the diminution of the floods. The natural result is that in proportion to the rainfall, floods have increased, the percentage of increase being 18.75 in the last half of the period as compared with the first half. This study is undoubtedly the most complete and authoritative that has ever been made of any American river, and it seems conclusive.

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[a] Floods in the United States, by M. O. Leighton, chief hydrographer, U. S. Geological Survey.

The low-water stages of a river are never a safe criterion on which to judge its real condition. A slight change in the bed of a stream may considerably affect the low stage at the point where the measurements are taken, though the real condition of the stream may not be changed in the least. In the same way a stream may actually raise its bed by silting, and thus the low-water stage may be increased while the actual condition is worse than at first. A study of the low-water data of the above table shows that intensified low-water conditions as signified by the measurements do not correspond in all cases with intensified flood conditions. Of the eight streams above referred to, four show apparently intensified and four apparently ameliorated low-water conditions. But for the reasons just stated, these records can not be depended upon as having any real significance in showing the actual flow.

The constant increase in the frequency and duration of floods in these streams appears not to be due to change in precipitation. In two cases there has been a slight increase in precipitation. These are on the Potomac watershed, where, as the table shows, there has been on the average 1.16 inches more rain in the second half than in the first half of the period. On the Wateree there was an increase of 2.02. On all of the other watersheds there has been a decrease ranging from 0.90 of an inch on the Monongahela to 6.34 inches on the Tennessee. It is thus clear that while floods have greatly increased in these streams the tendency has been toward decreased precipitation.

While the record is given for only eight streams which show increased floods, it must not be understood that these are the only streams which show this tendency; rather, they are examples—particularly they are examples of streams having their source in the Appalachian Mountains. They have been given because their records are more complete and longer than those for other streams. The records of most other streams of the region, so far as they are sufficient to show a tendency, indicate the same progressive change toward increased floods. For example, this is true of the Alabama River, of the Connecticut, of the Muskingum, and of the Congaree.

WHAT HAS CAUSED INCREASED FLOOD CONDITIONS?

Since it is apparent from the records that flood conditions have greatly intensified in many streams during the past two or three decades, it is important to consider the possible causes. Several factors are known to have an important influence upon stream flow. Chief among these are climate, topography, geology, natural or artificial reservoirs, soil, and ground cover. Climate must be understood as embracing precipitation and evaporation, with whatever influences them—notably, wind, humidity, temperature, and altitude. It is best to consider precipitation and evaporation separately, for they act in opposite directions and produce opposite effects.

PRECIPITATION.

It is, of course, apparent that precipitation must modify stream flow in a vital way, because no water can flow through the streams that does not first come down from the clouds. The amount of precipitation varies greatly from year to year. The amount for one year may be twice as great as for another in the same place, and at one point it may greatly exceed or fall short of that occurring a few miles away. While varying in a marked degree for short periods, precipitation becomes much more nearly constant through a long period.

If the precipitation had correspondingly increased over the Appalachian Mountain region, then it could be said that the greater and more frequent floods are due to that. But the figures which are given show that on only two of the eight watersheds mentioned in the table has there been any increase, and there by small amounts, while in the other six there has been a decrease, which in the case of one stream, the Tennessee, amounts to an average of 6 inches. The real tendency of the precipitation over these basins would therefore be to decrease flood conditions. Consequently, we must conclude that the increased flood conditions are in no degree due to precipitation.

EVAPORATION.

Taking the United States as a whole, less than half of the precipitation is said to pass through the rivers to the sea; the other part after a longer or shorter period, and after serving one purpose or another in nature's economy, goes back to the air through evaporation, except that portion which flows through underground courses to the sea.

Evaporation is fundamentally influenced by temperature, air pressure, wind, and humidity, and affects in a vital way both the regularity and amount of run-off of the streams. The Connecticut and Wateree rivers have about the same average annual precipitation—45 inches per year. Of this amount the run-off from the Connecticut watershed is 29 inches; from the Wateree watershed it is less than 18 inches. The difference is due to increased evaporation on the Wateree, where the temperature averages much higher. It is during the prolonged heated periods, which are often dry periods, that evaporation has greatest influence. It undoubtedly affects as much as any other factor the low-water stages of the streams, yet by its very nature it can not much influence floods, because they rise quickly and are never of many days' duration. There is not time for much water to evaporate. Hence we can put aside this climatic influence just as in this case we have put aside precipitation. We must look elsewhere for the cause.

TEMPERATURE.

Temperature, while influencing stream flow indirectly, through evaporation, also influences it directly. For example the upper watershed of the Monongahela River, in West Virginia, may be considered:

It is February, and there have been several weeks of cold weather; the ground, which is bare of snow, is frozen solid. There comes a heavy fall of snow, or perhaps several, bringing the snow cover to a depth of 12 to 18 inches. Within a few days the weather moderates and a prolonged rainy period follows. The first rain is caught by the snow and little escapes. But as it continues to come, it melts the snow so that the water from the snowfall and the rainfall is concentrated upon the surface at one time. If the ground were not frozen, much of it could be absorbed and distributed downward, but in the case we have assumed the earth is frozen solid, so that no water, or at least but little, can be absorbed. The whole volume is liberated on the surface and races away from the smaller streams to the larger, and at last, gathering in immense quantity, it overtaxes the channel of the main river and inundates the entire valley. It is this condition of rain, snow, and temperature operating together which brings about some of the greatest floods. A flood resulting from such a cause is not likely to occur more than once a year in any stream, and several years may pass without flood on a given watershed from this combination of causes. It can not be said that floods from this cause show any progressive change, and consequently we can not ascribe to this cause the increased flood conditions in the rivers now under consideration.

TOPOGRAPHY AND GEOLOGY.

A region's topography largely influences its run-off. Steep slopes and sharp ridges shed water quickly. A flat surface causes it to flow away more slowly.

Likewise, geology has a great deal to do with the drainage of any region. When rain has fallen and has passed through the soil cover and the soil, it comes in contact with the rocks which lie beneath. In obedience to gravity it will penetrate as deeply as possible. Considering the depth to which it can go and the quantity in which it can be stored, the earth forms a great storage reservoir which tends on most watersheds to have a strong influence toward steadiness in the flow of streams. While topography and geology are important factors in considering the amount and character of run-off, when one stream is compared with another, they are of no consequence when one is considering the condition in the same stream during two different periods, because they are subject to no appreciable variation. Both the topography and the geology of any given stream may be said to be constant, and so are not of importance in considering what has caused a changed condition of flow in any particular stream.

NATURAL AND ARTIFICIAL RESERVOIRS.

Some streams have on their watersheds great lakes which gather and hold immense volumes of water. A good example is the Merrimac River. On one of its important tributaries is that fine body of water, Lake Winnepesaukee; on another is Squam Lake, and, in addition, there are many smaller ones. Every natural reservoir of this kind tends to equalize the flow of the stream it feeds, because when its level is rising it is gathering in storage to pay out gradually the water which would otherwise run off at once. Moreover, on many of the lakes, espectially on those in New England, dams have been built at the outlets. By this means the water of the whole surface has been increased a number of feet in depth. In dry times when it is needed this water is emptied out. A large portion is thus taken off of the crest of each flood and added to low waters. Then, too, men may construct reservoirs where there were none before. It is considered feasible in some streams to construct such extensive reservoir systems as to store a large part of the flood waters. If this can be done, the flow of the streams can be made for all practical purposes even throughout the year.

If at the headwaters of the rivers under consideration in this paper there had been great lakes or swamps which had been drained during the period under consideration, it might well be said that the influence of that action would be sufficient to cause a difference in the run-off of the streams. But, except in the case of the Wabash, there have been no changes of this character. There are on these streams no important natural lakes, and no reservoirs of great extent have been developed. Consequently, this factor also is insignificant.

SOIL.

Though the topography and geology of a watershed change too slowly to be readily observed, there are other factors in which changes may be rapid, radical, and of great importance. One such factor is soil. The soil, when considered as a factor in controlling run-off, is a complicated and delicate apparatus. It works admirably when in good condition, but it is easily deranged and is liable to severe and fundamental injury, by which its action on storm water may be lessened or almost entirely destroyed. Mistreatment frequently produces results of a serious nature in the drainage of a watershed.

The mineral soil is composed of disintegrating rock that has broken down by the slow process of weathering. Deep mineral soils, if they have not accumulated from transported materials, represent a long period of rest, during which the surface has been free from erosion, while the disintegrating rock beneath has added little by little to the depth. Upon the mineral base, and more or less mixed with it, is the humus, which owes its existence to organic matter mostly vegetable, which has decayed and added the accumulated remnants to the mineral soil. Humus vastly increases a soil's capacity to absorb and store water.

The important work which soil performs in regulating the run-off for a region is easily understood. If the soil is present in sufficient quantity and good condition; that is, is porous and well supplied with humus, it readily absorbs storm water at the surface and passes it on downward through the underlying rocks and strata. Although these rocks themselves change but little, their storage of water is regulated by the soil and varies with its changes. If the soil is hardened or removed, the amount of water which can be taken in is correspondingly reduced, and the amount which is thrown off over the surface into the streams correspondingly increased. A watershed without soil or with a soil which does not readily perform its normal functions, results in erratic streams, which are usually agents of destruction rather than of use. The consideration of the flow of any stream should therefore take particular note of the soil and of the changes in its capacity for water storage.

GROUND COVER.

Scarcely separable from the soil itself is another factor of equal or greater importance in the disposition of water. This is the ground cover, or, to speak of it more particularly, the condition of the surface of the ground; that is, whether it is barren rock or clay, pasture land, cultivated land, or forest.

The condition of the surface does not influence very much, so far as known, the amount of water which falls. It is claimed by some that the precipitation is greater in the forest than on unforested land, and the figures given in the table at the beginning of this paper seem to indicate a tendency toward lessened precipitation on those watersheds which will presently be shown as having a decreased forest area. However, it is not intended at present to lay any stress upon that point. If the influence of the various factors which affect stream flow have been correctly stated, none of them is sufficient to have caused the increased floods. The natural conclusion is that the increase must be due to changes in the ground cover, or to the ground cover in conjunction with changes in the soil. Is the influence of the ground cover and of the soil sufficient to have caused the results?

It is generally agreed by those who have studied the subject most thoroughly that the forest offers the best conditions for absorption and underground storage. Next to the forest comes well-cultivated farm land; then meadow and pasture land; while the worst conditions of all are to be found on barren surfaces of stone, clay, or gravel, which because of infertility are unable to support growth of any kind.

The reasons why the forest offers the best conditions for absorption and ground storage are several. It does so, in the first place, because the foliage of the trees forms a storage place from which water drips slowly to the ground for a considerable length of time after each rain; because the complex layer of brush, leaves, weeds, mosses, and vines, all in a more or less advanced stage of decay, becomes filled with moisture with each heavy rain and holds it for a considerable time; because, also, the surplus water so stored continues to be absorbed by the upper humus-filled layers of earth; because, further, the temperature is lower and the air more humid in the forest than in the open; finally, because the snow lies there much longer. To these reasons must be added the mechanical power of the roots to go deep into the soil and break up the rocks, thus forming channels for the ready entrance of water into the earth.

On a level or slightly inclined surface a well-tilled soil may be as effective in absorbing and holding water as a forest soil. Where the slope exceeds 10 per cent, cultivation does not long go on before erosion sets in, and erosion if unchecked will remove the soil and gully the surface until all fertility has gone and all protective power is lost. Agriculture under right conditions may be an effective means of stream protection; under wrong conditions it may be the greatest menace to the even flow and usefulness of the streams.

THE PRINCIPAL CAUSES OF INCREASED FLOODS.

Undoubtedly it is the clearing away of the forest on the mountainous watersheds of the streams which have been described that has caused the great increase in frequency and duration of floods.

It is a known fact that the forests on these several watersheds have been cut away with great rapidity during the past thirty years. European conditions probably offer no parallel to the rate at which these watersheds have been cleared to make way for the rapid advance of agriculture and to supply the great manufacturing industries with the wood which they require. Forest lands, which offer the best possible conditions for soil absorption and underground storage, those great regulators of stream flow, have been changed to poorly tilled agricultural lands, which are not so good. Then these agricultural lands after a few years have been exhausted and their soil eroded into deep gullies. Finally, many of them have been turned into pasture or even entirely abandoned because they reached a condition where they could not support even a growth of grass and weeds. The best condition has been changed to the very worst condition.

Again, repeated burning of forest lands has tended to reduce the thickness and value of the ground cover and to lessen the power of the soil to absorb and to store water. The extent of damage from fire, so far as water storage is concerned, is generally vastly underestimated. A forest fire strikes both above and below the surface. It injures or kills the trees, destroys the undergrowth and brush, and consumes the great forest sponge—the ground cover and the humus. The extent of the injury is, of course, not always the same. It is sometimes slight; sometimes very great. Repeated fires tend to every kind of injury that can possibly be inflicted upon a forest soil, completely destroying the cover down to the mineral substances, and thus rendering it defenseless against the attacks of erosion. When that stage is reached, it may be depended upon that the run-off of the watershed has been profoundly affected, and the regimen of the stream materially changed. The fact that forest fires have repeatedly swept over the watersheds of the streams under consideration makes it easy to believe that this factor combined with the clearing away of the forest for agricultural purposes has been the chief cause of the intensified flood conditions which the records now disclose.

THE VITAL PART OF A WATERSHED.

Considering the streams which drain the mountain regions, the most vital parts of the watersheds are the highest parts. It is there that precipitation is the heaviest, slopes the steepest, and the whole sum of conditions most influential. Therefore, so far as stream flow is concerned, the mountains are the portion which should be given the most judicious care. It is on the mountains that the best condition of soil and ground cover should be maintained. As the best ground cover, as has already been explained, is the forest, it is to the benefit of the streams that the mountains should be kept densely forested, in order that the conditions for the absorption and retention of moisture may be as nearly as possible ideal. Under such conditions the course of the moisture will be one of continual interference from the time it reaches the crowns of the trees till it is in the stream.

Every obstruction that can be placed in the way of the water aids by that much the even flow of the rivers. Under perfect forest conditions it is well-nigh impossible for any surface run-off to take place. The rain first comes into contact with the crowns of the trees, and the drops are broken more or less into spray. Some of the intercepted water runs down the trunks or drips from the branches. That which escapes interception by the trees encounters the undergrowth and brush immediately above the ground and is intercepted and retarded. As the water continues to make its way downward the ground litter offers the next obstacle. The water is caught up by the litter, and not until this has become saturated can the water pass on. If the rain continues for some time the litter becomes filled to its capacity, and then the humus begins to absorb the water which the litter can not hold. After a time it, too, becomes saturated. The water then gradually filters into and through the underlying soil. If this is deep it stores water in large quantity and then allows the surplus to pass to still greater depths, where it finally penetrates the rock strata and replenishes the great underground reservoir, from which it emerges later as springs, some of which may be far removed, even on the opposite side of the mountain, from the place where it has come in contact with the ground. If the precipitation is in the form of snow its course is substantially the same, but with a still greater delay in passing through the litter and entering the soil. The period that may elapse between the fall of rain and the appearance of water in a river varies from minutes to months or even years.

Even with the best regulated system of checking and storing the rainfall a condition may arise where, to a large extent, the effect of obstruction and storage in a forest may temporarily be lost. Severe and prolonged freezing may result in a sheet of ice in and over the upper soil, which prevents the entrance of water, and whatever falls in the form of rain must at once run off into the streams. Many rivers experience their worst floods when their drainage basins are frozen. On account of this condition is is impossible to claim that extreme floods will not come in a stream with a forested watershed. Fortunately the condition arises but seldom.

In such cases the conditions are similar to what they would be were the covering of the soil removed. The disastrous floods which come once or twice in a generation when heavy rains descend upon snow and frozen ground would probably be duplicated or surpassed yearly, or several times a year, were the soil stripped from the mountain regions. The heavy rains of summer which now fall upon a dense vegetation and hardly affect the larger rivers would then produce destructive floods.

A COMPARATIVE STUDY OF WATERSHED CONDITIONS.

The table on a preceding page gives data regarding the flow of 10 important rivers of the United States. It has not been possible to obtain for each watershed a record of the changes which are believed to be responsible for the increased flood conditions which the record shows. It has been possible to make a detailed study of parts of the watersheds of two of the streams, the Cumberland and the Red.

A WATERSHED WHERE CONDITIONS HAVE GROWN WORSE.

The Cumberland River is a good example of how conditions have changed for the worse on some of these watersheds.

The drainage area of the Cumberland River above Burnside, Ky., comprises 3,739 square miles and lies in the heart of the Cumberland Mountains. The figures given in the table show that floods have increased in the Cumberland River at Burnside, Ky., in number from 32 in the first half to 43 in the second half, and in duration from 89 days in the first half to 102 days in the second half, while low waters have increased in times from 61 in the first half to 65 in the second half, and in days from 1,261 in the first half to 1,576 in the second half.

The removal of the forest on this watershed is progressing from three causes: (1) Clearing for agriculture; (2) lumber operations; (3) fires.

In 1890, when these measurements were begun, 21 per cent of the watershed above Burnside was cleared; in 1908 the cleared area had grown to 32 per cent. During the eight years from 1900 to 1908 clearing of forest for agricultural purposes went on on this watershed at the average rate of five-eighths of 1 per cent per year.

The total stand of timber on this part of the Cumberland watershed is 6,212,531,000 board feet. It is being cut away by lumbering alone at the rate of 4 per cent a year. These figures show that timber is disappearing on account of lumber operations eight times as fast as it is removed to clear land for farming purposes. In other words, supposing that lumbermen would cut clear as they go, 8 acres would be stripped for timber to 1 cleared for agriculture. The forest is not being cut clear. Instead, the lumberman is going over it time after time, picking out the particular kinds or classes of timber that he wants. First, he took the walnut and cherry; next, the white oak and poplar; now he is taking the chestnut and other kinds of oak. At the present time few tracts can be found from which one or more of the valuable timbers have not been culled. Other tracts have been stripped of nearly their entire growth.

At intervals of from one to five or six years fires run through the woods on the hills and mountains where the Cumberland River has its source. The fires are more frequent and destructive in districts where part of the timber has been cut and the refuse left on the ground. The dry ridges burn oftener than the coves, because the latter are sometimes too damp for burning. In times of prolonged drought, however, fires run through the ravines and coves where the densest growth is found. The fires are usually slow, and the damage to mature timber is not great, but the injury to the young growth is frequently excessive, and soil damage is serious. As a rule all seedlings and sprouts less than 4 or 5 feet high are killed, and, since fires come at intervals so frequent that the young growth can not attain a size above that, a large part of what would be the future forest, as well as the present ground cover, is destroyed. The surviving stand thus becomes thinner year by year, since it can not be replenished by young growth, and since the mature trees are steadily falling by natural decay or by the ax.

Though the fires are slow and small, they burn the leaf cover and the upper layers of humus at each visitation. This removes or injures the porous surface, one of whose essential functions is to arrest the storm water falling upon the slopes and afford it an opportunity to sink into the ground. With the packing of the surface, after the litter and humus have been burned away, the water flows down the slopes and quickly reaches the streams, where, if in sufficient quantity, it produces flood conditions. Low water follows, because the hard ground is able to take in but little of the storm water to be paid out slowly afterward.[a]

The behavior of the Cumberland River shows a direct and positive relation between the run-off and the changed condition of the surface. The changes due to agriculture and lumbering can be definitely stated, but the extent and effect of forest fires are not subject to exact calculation. Yet undoubtedly all of these influences are active in producing the results as shown in the flood and low water records at Burnside. It is impossible that these results should be due to rainfall, because the rainfall was approximately 10 per cent less in the second half of the period. Since no other influences could have produced the result, there is no conclusion possible other than that the progressive floods and low waters have been due to the changes accomplished on the surface of the watershed.

A WATERSHED WHERE CONDITIONS HAVE GROWN BETTER.

The fact that man by his operations may decidedly change the regimen of a river is shown not alone by those streams whose flow has been influenced by clearing away the forest. It is shown, on the other hand, by streams whose watersheds of prairie soil compacted for ages by the trampling of buffalo, and more recently by cattle of the great ranches of the West, have been to a large extent brought under cultivation.

A stream which shows this tendency in an unmistakable way is the Red River, which forms the boundary for many miles between Texas and Oklahoma. On this stream records of flow are available for sixteen years. The number of floods in the first half of this period was 19; in the second half, 16. The number of days of flood in the first half was 87; in the second half, 60. Considering also the low-water periods of this river, we find that in the first half of the period there were 49 periods of low water; in the second half there were 8. In the first half the duration of low water was 826 days; in the second half, 208 days. A falling off in the rainfall occurred on this watershed, there being 1.94 inches less water per year in the second than in the first. Its drainage basin is, and has been during the time of its known history, practically without forests, only 1 acre in 10 being forested. In that respect it differs from all eastern and many western rivers whose basins are more extensively forest covered.

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[a] A more definite statement regarding the damage to humus by fire may be made for the upper watershed of the Potomac River. In Water-Supply Paper, No. 192, the U. S. Geological Survey shows that 838 square miles of the forest of this watershed had been so severely burned by repeated fires as to completely or almost completely destroy the humus. Other tracts aggregating twice that area had their soil severely damaged, but not to the point of complete destruction of the humus. Considered together, these burned-over lands have an area of over 2,500 square miles, or 27 per cent of the drainage basin above the point of measurement. Assuming that the humus of the uninjured forest soil of the Potomac basin would hold back for absorption 2 inches of water, and assuming that with the humus damaged as in this case the capacity of the soil for receiving water is lessened one-half, then 1 inch will be held instead of 2 inches, as formerly. In an area of 2,500 square miles, the inch of water, which formerly was absorbed but now flows away quickly, amounts to about 6,000,000,000 feet. During a heavy rain that quantity of water in excess of what would flow off quickly before would go at once to the streams.

The rating table for the Potomac at Point of Rocks, where the measurements were made, shows that when the river is at a 10-foot stage 61,000 cubic feet of water pass per second. The 6,000,000,000 cubic feet of extra flood water from the burnt forest is therefore sufficient, without a gallon from other parts of the basin, to maintain a 10-foot stage at Point of Rocks for thirty hours. The effect on succeeding low-water stages is a logical one. There is simply 6,000,000,000 cubic feet less of stored water to come gradually after the rains cease.

Why has the Red River constantly changed its flow toward steadiness and uniformity, while many other rivers have changed in exactly the opposite direction? The area of the Red River drainage basin above Arthur City, Tex., where the records were made, is 40,200 square miles, divided almost equally between Oklahoma and Texas. In this river, as in those before mentioned, the geology and topography have not changed. The precipitation has changed considerably in the direction of lessened rainfall, but not enough to account for the record. In soil conditions, and especially in the condition of the surface, however, the change has been marked. At the beginning of the period of measurement, in 1890, the country was for the most part occupied by large ranches. The native prairie sod had never been broken up.

On the part of the watershed lying in Texas there had been some settlement at an early date, but as late as 1900 no more than 12 per cent of the Texas part of the watershed had been improved. In the Oklahoma part of the basin, in the same year, the improved portion was 16 per cent. Development began most extensively about 1900. In southwestern Oklahoma, in that portion drained by the Red River, it was stimulated by the opening of Indian reservations to settlement. The Cheyenne, the Arapahoe, and the Wichita lands were opened, it is true, in 1890, but the real opening of the country to settlers came in 1901, when the Comanche, the Apache, and other Indian lands were opened, aggregating over 10,000 square miles, or more than one-fourth of the entire Red River basin above Arthur City. Another tract of over 8,000 square miles, the Choctaw and Chickasaw lands, began its development about the same time. A summary of these figures shows that in 1908 the Red River basin in Oklahoma had 10,200 square miles of improved land, instead of 3,284 square miles in 1900. Statistics are not complete for the Texas portion of this basin, but the Texas portion has developed at about the same rate as the Oklahoma part. It is probable that the whole Red River basin above Arthur City, in Texas and Oklahoma, had 40 per cent of its land under improvement in 1908, instead of 14 per cent eight years earlier.

The results which have appeared in the form of change of the flow in the Red River are precisely what ought to be expected from the changes in surface conditions. Theoretically, such results should appear, and as a matter of fact, they have appeared. The hardened prairie soil has been broken up and changed into cultivated fields over 40 per cent of the area, and thereby the absorptive capacity of the soil has been much increased. Over the remainder prairie fires have been kept out and better growth of grass secured. The extensions of cultivation and the improvement of the grass land has tended to equalize the flow of this river. The river's behavior has become better as the area of wild land has decreased. In other words, wild, barren land, being the worst condition for the protection of a watershed, and cultivated farm lands being next to forests the best condition, the change of a large part of the watershed from the worst condition to the next to the best condition has brought about this result.

The same law is thus seen to work on both the Cumberland and the Red River watersheds, but in different directions. On the Cumberland, as the watershed changes from the forest (the best condition for stream protection) to farm land, to pasture land, and even to barren condition (the very worst condition for absorption), the flow of the river is made more extreme, both as to floods and low waters. On the Red watershed, beginning with a wild, almost barren, compacted surface, cultivation has changed the condition to that of permeable farm lands, which, next to forests, offer the best conditions. These two extremes exemplify, therefore, in different directions, the working of the same law—that there is a vital relation between the condition of the surface of the watershed and the manner of flow of the stream which drains it.

DENUDATION.

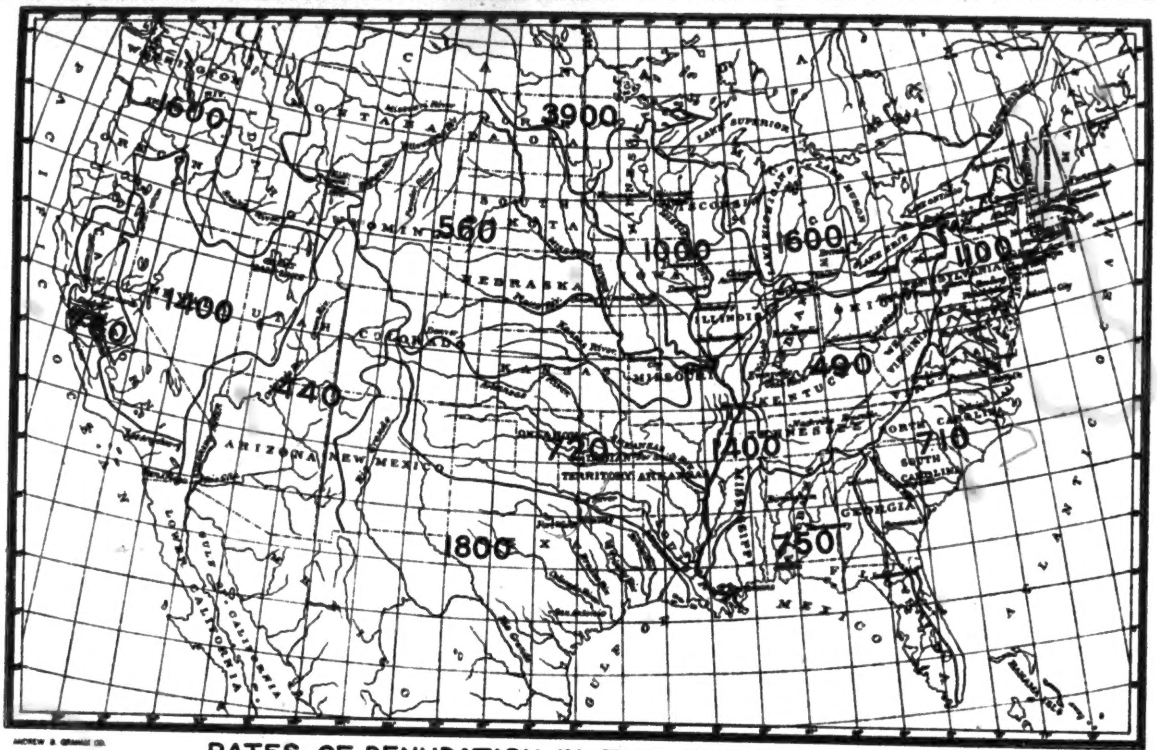
By R. B. Dole and H. Stabler,
Water Resources Branch, United States Geological Survey.

INTRODUCTION.

The accompanying tables present estimates of the rate of denudation in the United States. The figures show the rate at which the earth's crust is being moved as solid particles carried in suspension by streams and as matter carried in aqueous solution. The first table is a summary of the estimated denudation for the whole United States and for the primary drainage basins; the other tables contain detailed estimates for smaller areas. The map indicates graphically the rates of denudation in different parts of the country.

SOURCES OF DATA.

The computations of denudation factors are based on figures representing the amount of mineral matter carried by streams, the size of the areas tributary to the streams, and the quantity of water discharged by the streams. The run-off data are derived principally from measurements made by the water-resources branch of the United States Geological Survey; some of the measurements, especially in lower Mississippi Valley and on the Great Lakes, were made by the Engineer Corps, U. S. Army; the Weather Bureau, Department of Agriculture, has contributed series of gage heights in several streams; and estimates of run-off based on the best available information have been made for areas regarding which no measurements are at hand. The estimates of the size of the drainage basins are either copied from printed reports or measured from the best available maps. The greater part of the chemical data are derived from complete mineral analyses of river waters, about 5,000 in all, performed for the water-resources branch under the direction of R. B. Dole by W. M. Barr, F. W. Bushong, C. K. Calvert, W. D. Collins, F. M. Eaton, J. R. Evans, P. L. McCreary, Chase Palmer, J. L. Porter, M. G. Roberts, F. C. Robinson, Walton Van Winkle, and A. J. Weith. Daily samples of water were collected for one year from about 150 rivers and lakes in California and in the States east of the one hundredth meridian. Ten consecutive samples were then united and the composites thus obtained were subjected to complete mineral analysis. The information regarding dissolved and suspended matter in the streams of the arid States, except California, has been furnished by the United States Reclamation Service from work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ARIZONA
NEW MEXICO
TERRITORY
ARKANSAS
MISSISSIPPI
GEORGIA
SOUTH CAROLINA
NORTH CAROLINA
WEST VIRGINIA
LAKE SUPERIOR
LAKE HURON
LOWER CALIFORNIA
GULF OF CALIFORNIA
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
CANADA

ANDREW B. GRAHAM CO.

RATES OF DENUDATION IN THE UNITED STATES
The figures are the number of years required for one inch of denudation.

Senate Doc. No. 676; 60th Cong., 2d. Sess.

done under the direction of W. H. Heileman, but unfortunately the detailed analyses could not be procured and therefore the comparative accuracy of the estimates is unknown. In the California and the Reclamation Service work 50 cubic centimeters of filtered and 50 cubic centimeters of unfiltered sample were evaporated, dried at 110° C., and weighed to determine suspended and dissolved solids. In the other analyses the suspended matter in 500 cubic centimeters of the sample was removed by filtration through a Gooch crucible, dried at 180° C., and weighed for suspended solids; the filtrate was then evaporated, dried at 180° C., and weighed for dissolved solids. Some error is introduced by comparing solids determined at 180° with solids determined at 110°. The size of the error varies with the amount of organic matter and water of crystallization present and with the character of the solids themselves, and is probably variable for different rivers and for the same river from time to time; consequently no correction for it has been made. In most cases, however, this circumstance introduces less than 10 per cent error.

The figures for Kennebec River are computed from analyses by G. C. Whipple and E. C. Levy. The dissolved solids for Connecticut River and for Housatonic River are from reports of the Connecticut state board of health; for Merrimac River, from reports of the Massachusetts state board of health; for Blackstone River, from reports of the Rhode Island state board of health. The data for Hudson River at Albany, N. Y.; Potomac River at Great Falls, Md.; and Allegheny River at Pittsburg, Pa., are from reports of water-supply investigations at those places. The figures for Colorado River at Yuma, Ariz., are computed from analyses by R. H. Forbes and from others made in continuation of his work by the Reclamation Service. The data for Ohio River at Louisville, Ky., and at Cincinnati, Ohio, are quoted from reports by G. W. Fuller. The data at West Alton and at Jefferson Barracks, Mo., are quoted from analyses by A. W. Palmer in connection with the case of the State of Missouri against the State of Illinois and the sanitary district of Chicago. The estimates of suspended and dissolved solids at New Orleans, La., are computed from fifteen years' sediment determinations by the Engineer Corps, U. S. Army, and from five years' determinations by the New Orleans water and sewerage board. In all the quoted analyses the estimates are given by weight and not by volume, and in nearly all cases they show the average condition of the water for one or more years.

METHODS OF COMPUTATION.

The estimates of denudation, computed from the above-mentioned data by H. Stabler, indicate the removal in solution and suspension of solids from the primary and secondary drainage basins of the United States as classified by the Geological Survey. The determinations on which the computations are based are given in detail. The eleven primary basins are designated by Roman numerals. Under the secondary basins, which are designated by Arabic figures, important tributaries and the sampling stations are indicated.

The second, third, fourth, and fifth columns of the tables give, respectively, the areas of the basins, the dissolved solids, the suspended solids, and the annual run-off per square mile. In columns 6 and 7 the annual denudation in tons per square mile for the areas above the points at which samples were collected is computed by multiplying together solids in parts per 1,000,000, run-off in second-feet per square mile, and 0.985; in all other regions the denudation is estimated from the data for known areas. Columns 8 and 9 show the total denudation in thousands of tons per year, computed for the secondary areas by multiplying denudation in tons per square mile per year by the drainage area in thousands of square miles.

The depth in millionths of an inch per year covered by the material removed is found by dividing the tons per square mile per year by 0.1917 and the last three columns bear reciprocal relations to columns 10, 11, and their sum. Any attempt to estimate erosion in volumetric terms from determinations of dry suspended matter and dissolved solids involves the use of factors which are by no means absolute. The actual specific gravity of the mineral substance carried in streams in the United States is not greatly different from 2.6. This figure is practically identical with that commonly assumed for the specific gravity of the earth's crust and corresponds to a weight of 165 pounds per cubic foot. Each 165 pounds of substance found in water, therefore, represents the erosion of approximately 1 cubic foot of the crust of the earth, and estimates of ultimate rock losses based upon these figures are probably not in error more than 8 or 10 per cent. Common earth or loam, however, contains a large amount of air space, or voids, and dry earth is estimated as weighing 80 to 110 pounds per cubic foot. If an estimate of erosion be made upon this basis the error for a large area will probably not be great, but may amount to 20 per cent or more when calculations are made for small areas. Finally a third factor for calculation is based upon an attempt to determine the volume of river sediment or mud banks that a given weight of suspended matter may form. Investigators working upon different streams in the United States have obtained results indicating that a cubic foot of sediment may be produced by 50 to 125 pounds of dry material. The compactness of the mud is so variable that an estimate of this nature based upon an average of 90 pounds per cubic foot is likely to be in error by about 45 per cent. In view of the widely divergent values given for river sediment and for surface loam, the estimates for denudation expressed in millionths of an inch in depth from the entire drainage area and in years required for the erosion of 1 inch from the drainage area are based upon the assumption that 165 pounds of suspended or dissolved solids represent the removal of 1 cubic foot of the earth's crust. The factor 0.1917 has been computed on that basis. For the convenience of those who prefer a different basis of calculation, the following table of ratios is presented. The figures given in this report for denudation in inches can be recomputed by dividing them by the ratio corresponding to the weight given in column 1.

Ratios for recomputing denudation in inches.

Weight of material per cubic foot.	Corresponding specific gravity.	Ratio.
Pounds.		
165	2.64	1.00
150	2.40	.91
140	2.24	.85
130	2.08	.79
120	1.92	.73
110	1.76	.67
100	1.60	.61
90	1.44	.55
80	1.28	.49
70	1.12	.42
60	.96	.36
50	.80	.30

The estimates for the primary basins and for the whole United States are based upon the estimates for the secondary areas.

PROBABLE ACCURACY.

The majority of the figures for run-off per square mile per year are based upon discharge measurements extending over periods of seven years or more and are, with a few exceptions, within 10 per cent of the true average values. The drainage areas in square miles are so nearly correct that their errors are negligible in these calculations. The estimates of dissolved solids represent the average condition of the water for a period of one year or more. By comparison of annual averages for several streams in different years it has been estimated that the average for one year is generally not over 10 per cent from the correct average value, and it is undoubtedly true that the average total solids does not vary from year to year nearly so much as the average run-off. On the other hand, suspended solids are subject to greater variation than run-off. Floods are always attended by extreme rises in suspended solids, and the amount of suspended matter is subject to enormous variation from place to place on account of changes in stream velocity, the character of the river bed, and other features. In consequence of these facts, it is possible that denudation estimates, based on average suspended matter for one year, may be in error as much as 50 per cent. When all these facts are considered in conjunction with the distance of the sampling stations from the mouths of the rivers, it may be estimated that the calculated figures for denudation are generally within 20 per cent of the true values. Only two significant figures, therefore, have been retained in the last five columns. In many streams of the arid and semiarid regions the yearly fluctuations in run-off are very great and the mineralization of the waters is very high, so that estimates of denudation in that part of the country are not so reliable as similar estimates for eastern rivers. As the analytical data for the northern Pacific, Hudson Bay, and western Gulf of Mexico basins are extremely meager, the estimated denudations for those areas may be more than 20 per cent in error, and further investigations in those regions must be made before reliable values can be calculated.

DISCUSSION OF SUMMARY.

The summary presents in tabular form denudation estimates for the primary drainage basins and for the whole United States. The figures for dissolved solids practically represent material carried into the ocean; the figures for suspended solids, on the other hand, represent more properly material carried to tide water, because the decrease in stream velocity at that point occasions a gradual deposition of the matter transported in solid form. The tons per square mile per year removed from different basins show interesting comparisons. In respect to dissolved matter, the southern Pacific basin heads the list with 177 tons, the northern Atlantic basin being next with 130 tons. The rate for Hudson Bay basin, 28 tons, is lowest; that for the Colorado and western Gulf of Mexico basins is somewhat higher. The denudation estimates for the southern Atlantic basin correspond very closely to those for the entire United States. The amounts are generally lowest for streams in the arid and semiarid regions, because large areas there contribute little or nothing to the run-off. The southern Pacific basin is an important exception to this general rule, presumably because of the extensive practice of irrigation in that area. The amounts are highest in regions of high rainfall, though usually the waters in those sections are not so highly mineralized as the waters of streams in arid regions.

Colorado River brings down the most suspended matter, delivering 387 tons per year for each square mile of its drainage basin. Though many small streams bring silt into the Great Lakes, sedimentation clears the water, and practically no suspended matter is transported by St. Lawrence River. In general much less suspended matter is carried by northern than by southern rivers, a phenomenon influenced probably more by the texture of the soil and the subsoil and the geologic character of the rocks than by stream velocity.

The detailed estimates throw considerable light upon the progress of erosion in different sections of the river valleys. The Mississippi, for instance, apparently discharges more material than is brought in by its tributaries, thus indicating that its lower valley is still being eroded. The lower Colorado, however, appears to be receiving deposits from both dissolved and suspended matter taken from its upland drainage area. The Rio Grande is similar to the Colorado in this respect.

The estimates reveal that the surface of the United States is being removed at the rate of thirteen ten-thousandths of an inch per year, or 1 inch in 760 years. Though this amount seems trivial when spread over the surface of the country, it becomes stupendous when considered as a total, for over 270,000,000 tons of dissolved matter and 513,000,000 tons of suspended matter are transported to tide water every year by the streams of the United States. This total of 783,000,000 tons represents more than 350,000,000 cubic yards of rock substance, or 610,000,000 cubic yards of surface soil. If this erosive action had been concentrated upon the Isthmus of Panama at the time of American occupation, it would have excavated the prism for an 85-foot level canal in about seventy-three days.

Summary.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dissolved.	Suspended.		Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Total.
I. Northern Atlantic	159,400	....	....	....	130	39	20,800	6,100	680	200	1,500	5,000	1,100
II. Southern Atlantic	123,900	....	....	....	94	176	11,700	21,800	490	920	2,000	1,100	710
III. Eastern Gulf of Mexico	142,100	....	....	....	117	144	16,600	20,400	580	750	1,700	1,300	750
IV. Western Gulf of Mexico	315,700	....	....	....	36	72	11,400	22,700	190	380	5,300	2,700	1,800
V. Mississippi River	1,265,000	....	....	....	108	269	136,400	340,500	560	1,400	1,800	710	500
VI. Laurentian Basin	175,000	....	....	....	116	1	20,400	180	600	5	1,700	200,000	1,610
VII. Colorado River	230,000	....	....	....	51	387	11,700	89,000	270	2,000	3,800	500	440
VIII. Southern Pacific	72,700	....	....	....	177	75	12,800	5,500	920	390	1,100	2,600	760
IX. Northern Pacific	270,000	....	....	....	100	20	27,000	5,400	520	100	1,900	9,600	1,600
X. Great Basin	223,000	....	....	....	90	50	20,100	11,200	470	260	2,100	3,800	1,400
XI. Hudson Bay	62,000	....	....	....	28	21	1,700	1,300	150	110	6,800	9,100	3,900
Total	3,048,800	....	....	....	....	....	290,600	524,080	....	....	....	....	....
The United States	3,088,500	....	....	....	94	170	290,600	524,080	490	880	2,040	1,130	730
The United States (Great Basin denudation being taken as zero)	3,088,500	....	....	....	87	166	270,500	512,880	460	870	2,190	1,150	760

Detailed estimates.

Drainage basin.	Physical and chemical data.				Estimated denudation.									
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.			
		Dis-solved.	Sus-pended.		Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Total.
I. Northern Atlantic	150,400				130	30	20,795	6,147	[illegible]	200	1,500	5,000	1,100
1. St. Johns (in United States)	7,500			1.76	85	7	638	53	440	37	2,300	27,000	2,100
2. St. Croix (in United States)	1,100			2.61	100	8	110	9	520	42	1,900	24,000	1,800
3. Penobscot	8,500			1.96	90	8	765	68	470	42	2,100	24,000	2,000
4. Kennebec	5,970			1.84	85	7	508	42	440	37	2,300	27,000	2,100
Waterville, Me.	4,270	48	4.0	1.76	83	7.3							
5. Androscoggin	3,500			2.14	100	8	350	28	520	42	1,900	24,000	1,800
Brunswick, Me	3,500	48		2.14	101								
6. Presumpscot	600			1.68	85	7	51	4	440	37	2,300	27,000	2,100
7. Saco	1,720			2.36	100	8	172	14	520	42	1,900	24,000	2,100
8. Merrimac	5,020			1.62	65	7	326	35	340	37	3,000	27,000	2,700
Lawrence, Mass	4,550	41		1.58	64								
9. Connecticut	11,100			1.99	90	8	990	89	470	42	2,100	24,000	2,000
Goodspeeds, Conn	10,900	45		1.99	88								
10. Blackstone	400				125	7	58	3	650	37	1,500	27,000	1,500
Valley Falls, R. I	440	74		1.71	125								
11. Thames	1,450				125	7	181	10	650	37	1,500	27,000	1,500
12. Housatonic	1,980			2.17	195	8	386	16	1,000	42	980	24,000	940
Gaylordsville, Conn	1,020		4.0	2.15		8.5							
Derby, Conn	1,920	92		2.15	195								
13. Hudson	13,400			1.90	190	30	2,544	402	990	160	1,000	6,400	870
Albany, N. Y	8,800	107	17.0	1.80	189	30							
Hudson, N. Y	9,530	108	16.0	1.82	193	29							
Mechanicsville, N. Y	4,500			1.81									
Dunsback Ferry (Mohawk River)	3,440			1.73									
14. Passaic	950			2.17	180	75	171	71	940	390	1,100	2,600	750
15. Raritan	1,110			2.15	180	75	200	83	940	390	1,100	2,000	750
Bound Brook, N. J	800	85	36.0	2.14	179	76							
16. Delaware	13,100			1.97	150	55	1,964	721	780	290	1,300	3,500	940
Lambertville, N. J	6,860	70	26.0	2.19	151	56							
17. Susquehanna	27,400			1.56	165	35	4,520	900	800	180	1,200	5,500	960
Danville, Pa	11,070	112	21.0	1.71	188	35							
Williamsport, Pa	5,640	74	18.0	1.68	123	30							
18. Potomac	14,300			1.21	125	95	1,787	1,358	650	500	1,500	2.000	870
Piedmont, W. Va	410			1.70									

Cumberland, Md.	620	130	29.0	1.70	217	49							
Millville, W. Va. (Shenandoah River)	3,000	140	30.0	1.07	147	41							
Point of Rocks, Md	9,650			1.07									
Great Falls, Md	11,400	115	85.0	1.12	127	94							
19. James	10,400			1.35	115	95	1,195	988	600	500	1,700	2,000	900
Cartersville, Va.	6,230			1.33									
Richmond, Va.	6,820	89	71.0	1.33	117	93							
20. Minor Chesapeake Bay	12,800			1.59	130	40	3,870	1,193	680	210	1,500	4,800	1,100
21. Minor North Atlantic	17,000			2.18									
II. Southern Atlantic	123,900				94	176	11,688	21,775	490	920	2,000	1,100	710
1. Chowan	5,000			1.40	85	80	425	407	440	420	2,300	2,400	1,200
2. Roanoke	9,750			1.25	101	256	984	2,490	530	1,300	1,900	750	540
South Boston, Va. (Dan River)	2,750	71	264.0	1.34	94	348							
Randolph, Va.	3,080	79	127.0	1.39	108	174							
3. Tar	4,360			1.26	85	80	371	349	440	420	2,300	2,400	1,200
4. Neuse	5,550			1.32	86	80	477	444	450	420	2,200	2,400	1,200
Raleigh, N. C	1,000	73	68.0	1.19	86	80							
Selma, N. C	1,170			1.19									
5. Cape Fear	9,030			1.23	69	25	623	226	300	130	2,800	7,700	2,000
Wilmington, N. C	9,030	57	21.0	1.23	69	25							
6. Pedee (Yadkin)	10,600			1.60	113	154	1,198	1,630	590	800	1,700	1,200	720
Salisbury, N. C	3,400			1.69									
Pee Dee, N. C	6,100	69	94.0	1.66	113	154							
7. Santee	14,800			1.66	107	233	1,583	3,445	560	1,200	1,800	820	560
Camden, S. C. (Wateree River)	4,500	73	214.0	1.44	104	303							
Waterloo, S. C. (Saluda River)	1,060			1.85									
Columbia, S. C. (Saluda River)	2,350	62	54.0	1.85	113	98							
8. Savannah	11,100			1.58	98	232	1,068	2,575	510	1,200	2,000	830	580
Augusta, Ga.	7,300	60	142.0	1.66	98	232							
9. Ogeechee	5,140			1.27	90	225	463	1,156	470	1,200	2,100	850	610
10. Altamaha	14,100			1.26	85	215	1,198	3,030	440	1,100	2,300	890	640
Macon, Ga. (Ocmulgee River)	2,420	69	174.0	1.31	86	224							
Dublin, Ga. (Oconee River)	4,180	68	171.0	1.24	83	209							
11. Minor South Atlantic	34,500				95	175	3,278	6,030	500	910	2,000	1,100	710
III. Eastern Gulf of Mexico	142,100				117	144	16,610	20,430	580	750	1,700	1,300	750
1. Suwanee	9,970			1.50	100	150	997	1,500	520	780	1,900	1,300	770
2. Apalachicola	18,800			1.61	103	159	1,936	2,988	540	830	1,900	1,200	730
Albany, Ga. (Flint River)	5,000	67	58.0	1.56	103	89							
West Point, Ga. (Chattahoochee River)	3,300	52	136.0	1.98	102	265							
3. Mobile	42,100			1.57	129	151	5,190	6,350	670	790	1,500	1,300	680
Selma, Ala. (Alabama River)	15,400	82	100.0	1.81	146	178							
Epes, Ala. (Tombigbee River)	8,830	94	100.0	1.06	98	104							

Detailed estimates—Continued.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dis-solved.	Sus-pended.		Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Total.
III. Eastern Gulf of Mexico—Continued.													
4. Pearl	8,650			1.42	75	58	649	502	390	300	2,600	3,300	1,400
Jackson, Miss.	3,120	59	46.0	1.29	75	58							
5. Minor Eastern Gulf	62,700			1.50	125	145	7,838	9,090	650	760	1,500	1,300	710
IV. Western Gulf of Mexico	315,700				36	72	11,370	22,740	190	380	5,300	2,700	1,800
1. Brazos	48,800			.200									
Waco, Tex.	32,300	1,136	1,188.0	.082	92	96	2,970	3,100					
2. Colorado (of Texas)	39,000			.097	24	26							
Austin, Tex.	35,000	321	351.0	.075	24	26	878	952					
3. Rio Grande	248,000			.032									
United States area	130,000				25	78	3,250	10,140					
El Paso, Tex.	38,600	700	14,140.0	.030	21	418							
Laredo, Tex. (United States area)	123,000	791	2,475.0	.032	25	78							
Pecos River	56,000				90	60							
Dayton, N. Mex.	16,300	2,968	2,150.0	.032	94	68							
Carlsbad, N. Mex.	19,800	2,680	331.0	.035	92	11							
V. Mississippi River:													
1. Main stream—													
Minneapolis, Minn.	19,600	200	7.9	.810	159	6.3	3,120	124	830	33	1,200	30,000	1,200
Quincy, Ill.	135,500	203	119.0	.538	108	63							
Jefferson Barracks, Mo.	700,700	206	964.0	.263	53	250							
Menard, Ill.	711,900	200	634.0	.263	70	164							
Memphis, Tenn.	941,000	202	519.0	.546	109	279							
New Orleans, La.	1,261,000	190	600.0										
At mouth	1,265,000			.500	105	331							
2. Minor lower eastern—													
Tributaries	29,000				80	60	2,320	1,740	420	310	2,400	3,200	1,400
3. Ohio River	214,000				190	200	40,600	42,750	990	1,000	1,000	960	490
Tennessee River	39,000				159	200							
Chattanooga, Tenn.	21,400			1.71									
Gilbertsville, Ky.	38,400	101	127.0	1.60	150	200							
Cumberland River	18,600				171	227							
Kuttawa, Ky.	18,200	124	165.0	1.40	171	227							

Green River	8,580				165	225							
Kentucky River	7,870				164	220							
Frankfort, Ky	5,140	104	142.0	1.60	164	223							
Licking River	3,300				160	220							
Big Sandy River	4,000				160	200							
Kanawha River	11,000				160	180							
Monongahela River	7,620				217	203							
Elizabeth, Pa	5,580	81	84.0	1.80	143	149							
McKeesport, Pa. (Youghiogheny River)	1,770	197	163.0	2.30	446	369							
Allegheny River	11,100				160	60							
Kittanning, Pa	8,690	87	30.0	1.62	139	48							
Brilliant, Pa	11,000	116	48.0		185	77							
Beaver River	3,100				180	65							
Muskingum River	7,740				232	67							
Zanesville, Ohio	5,830	244	70.0	.966	232	67							
Scioto River	6,400				220	68							
Great Miami River	5,400				210	68							
Dayton, Ohio	2,450	289	94.0	.737	210	68							
Wabash River	33,000				249	86							
Terre Haute, Ind	12,200			.737									
Vincennes, Ind	12,720	336	193.0		244	140							
White River	10,800				290	38							
Indianapolis, Ind. (West Fork)	1,520	450	38.0	.792	351	30							
Azalia, Ind. (East Fork)	2,100	279	48.0	.900	247	43							
Shoals, Ind. (East Fork)	4,900			.924									
Embarass River	2,450				212	49							
Lawrenceville, Ill	2,390	283	66.0	.76	212	49							
Little Wabash River	2,600				133	52							
Carmi, Ill	2,500	176	68.0	.77	133	52							
Minor tributaries	56,800												
Main stream:													
Wheeling, W. Va	23,800			1.72									
Cincinnati, Ohio	72,400	120	230.0	1.60	189	363							
Louisville Ky	85,000	150	350.0	1.50	221	517							
4. Big Muddy River	2,370				170	98	400	230	890	510	1,100	2,000	720
Murphysboro, Ill	2,250	225	129.0	.77	170	98							
5. Kaskaskia River	5,880				180	92	1,060	540	940	480	1,100	2,100	700
Carlyle, Ill	2,720	248	126.0	.74	180	92							
6. Illinois River	27,900				218	118	6,080	3,290	1,100	620	880	1,600	570
Kampsville, Ill	26,730	267	145.0	.83	218	118							
7. Rock River	10,970				200	180	2,190	1,970	1,000	940	960	1,100	500
Rockton, Ill	6,150			.773									
Rock Falls, Ill	8,640	267	236.0		203	179							
8. Wisconsin River	12,280				140	7	1,720	86	730	37	1,400	27,000	1,300
Necedah, Wis	5,800			1.45									
Portage, Wis	8,600	98	4.6		140	6.6							
9. Chippewa River	9,570				116	5	1,110	48	600	26	1,700	38,000	1,600
Eau Claire, Wis	6,740	90	3.7	1.31	116	4.7							
10. St. Croix River	7,660				120	5	920	38	630	26	1,600	38,000	1,500

Detailed estimates—Continued.

Drainage basin.	Physical and chemical data.				Estimated denudation.									
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.			
		Dis-solved.	Sus-pended.		Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Total.
V. Mississippi River—Continued.													
11. Minor upper:													
Eastern tributaries	10,000	......	......	......	180	90	1,800	900	940	470	1,100	2,100	710
12. Minnesota River	16,100	......	......	......	89	26	1,420	418	460	140	2,200	7,400	1,700
Mankato, Minn	13,400	......	......	0.186	......	......	......	......	......	......	......	......	......
Shakopee, Minn	15,100	480	142.0	......	88	26	......	......	......	......	......	......	......
13. Wapsipinicon River	2,570	......	......	......	145	50	370	128	760	260	1,300	3,800	980
14. Iowa River	12,400	......	......	......	145	50	1,800	620	760	260	1,300	3,800	980
Iowa City, Iowa	3,320	247	120.0	.573	139	68	......	......	......	......	......	......	......
Cedar Rapids, Iowa (Cedar River)	6,320	228	61.0	.656	147	39	......	......	......	......	......	......	......
15. Des Moines River	14,700	......	......	......	169	349	2,480	5,130	880	1,800	1,100	550	370
Keosauqua, Iowa	14,300	312	642.0	.551	160	349	......	......	......	......	......	......	......
16. Missouri River	528,000	......	......	......	50	290	26,400	153,100	200	1,500	3,800	660	560
Florence, Nebr	323,000	454	2,059.0	.154	69	312	......	......	......	......	......	......	......
Omaha, Nebr	323,000	......	......	.154	......	......	......	......	......	......	......	......	......
Kansas City, Mo	430,000	426	2,032.0	.143	60	286	......	......	......	......	......	......	......
Ruegg, Mo	528,000	346	1,890.0	.157	53	292	......	......	......	......	......	......	......
West Alton, Mo	528,000	294	1,138.0	.157	45	176	......	......	......	......	......	......	......
Milk River	26,700	......	......	......	......	......	......	......	......	......	......	......	......
Havre, Mont	7,300	712	1,331.0	.035	25	46	......	......	......	......	......	......	......
Yellowstone River	69,700	......	......	......	......	......	......	......	......	......	......	......	......
Glendive, Mont	66,000	375	853.0	.188	70	158	......	......	......	......	......	......	......
Platte River	83,800	......	......	......	......	......	......	......	......	......	......	......	......
Fremont, Nebr	71,400	302	392.0	......	39	51	......	......	......	......	......	......	......
Columbus, Nebr	70,400	......	......	.132	......	......	......	......	......	......	......	......	......
Kansas River	61,400	......	......	......	......	......	......	......	......	......	......	......	......
Lecompton, Kans	58,600	......	......	.191	......	......	......	......	......	......	......	......	......
Holliday, Kans	61,100	383	612.0	......	72	115	......	......	......	......	......	......	......
17. Arkansas River	189,000	......	......	......	120	140	22,700	26,450	630	730	1,600	1,400	740
Arkansas City, Kans	44,500	1,284	1,736.0	.045	57	77	......	......	......	......	......	......	......
Little Rock, Ark	158,000	630	748.0	.197	122	145	......	......	......	......	......	......	......
18. Red River	90,000	......	......	......	160	240	14,400	21,600	840	1,300	1,200	800	480
Shreveport, La	56,900	561	870.0	.285	157	244	......	......	......	......	......	......	......
19. Minor western tributaries	63,000	......	......	......	145	50	9,140	3,150	760	260	1,300	3,800	980

Cumulative summary:													
1. Above Quincy, Ill.:													
Mississippi at Minneapolis, Minn	19,600				159	6.3	3,120	124	830	33	1,200	30,000	1,200
Minnesota River	16,100				88	26	1,420	418	460	140	2,200	7,400	1,700
Wapsipinicon River	2,570				145	50	370	128	760	260	1,300	3,800	980
Iowa River	12,400				145	50	1,800	620	760	260	1,300	3,800	980
Des Moines River	14,700				169	349	2,480	5,130	880	1,800	1,100	550	370
St. Croix River	7,660				120	5	920	38	630	26	1,600	38,000	1,500
Chippewa River	9,570				116	5	1,110	48	600	26	1,700	38,000	1,600
Wisconsin River	12,280				140	7	1,720	86	730	37	1,400	27,000	1,300
Rock River	10,970				200	180	2,190	1,970	1,000	940	960	1,100	500
Minor streams	29,650				157	63	4,660	1,880	820	330	1,200	3,000	870
Mississippi at Quincy, Ill	135,500												
Estimated from tributaries					146	77	19,790	10,442	760	400	1,300	2,500	860
Actually determined					108	63	14,640	8,540	560	330	1,800	3,000	1,100
Average					127	65	12,215	9,491	660	340	1,500	3,000	1,000
2. Above Menard, Ill.:													
Mississippi at Quincy, Ill	135,500				146	77	19,790	10,442	760	400	1,300	2,500	860
Illinois River	27,900				218	118	6,080	3,290	1,100	620	880	1,600	570
Missouri River	528,000				50	290	26,400	153,100	260	1,500	3,800	660	560
Kaskaskia River	5,880				180	92	1,060	540	940	480	1,100	2,100	700
Minor streams	14,620				145	50	2,120	731	760	260	1,300	3,800	980
Mississippi at Menard, Ill	711,900												
Estimated from tributaries					78	236	55,450	168,103	410	1,200	2,500	810	610
Actually determined					70	164	49,850	116,700	360	860	2,700	1,200	820
Average					74	200	52,650	142,402	390	1,000	2,600	960	700
3. Above Memphis, Tenn.:													
Mississippi at Menard, Ill	711,900				78	236	55,450	168,103	410	1,200	2,500	810	610
Big Muddy River	2,370				170	98	400	230	890	510	1,100	2,000	720
Ohio River	214,000				190	200	40,600	42,750	990	1,000	1,000	960	490
Minor streams	12,730				145	50	1,840	636	760	260	1,300	3,800	980
Mississippi at Memphis, Tenn	941,000												
Estimated from tributaries					104	225	98,290	211,719	540	1,200	1,800	850	580
Actually determined					109	279	102,500	262,400	570	1,500	1,800	690	490
Average					106	252	100,395	237,060	550	1,300	1,800	760	540

Detailed estimates—Continued.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dissolved.	Suspended.		Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Dissolved.	Suspended.	Total.
V. Mississippi River—Continued.													
Cumulative summary—Continued.													
4. Mouth of river:													
Mississippi at Memphis, Tenn.	941,000				104	225	98,290	211,719	540	1,200	1,800	850	580
Arkansas River	180,000				120	140	22,700	26,450	630	730	1,600	1,400	740
Red River	90,000				160	240	14,400	21,600	840	1,300	1,200	800	480
Minor streams	45,000				103	56	4,640	2,540	540	290	1,900	3,400	1,200
At mouth	1,265,000												
Estimated from tributaries.					111	208	140,030	262,309	580	1,100	1,700	920	600
Determined from analyses at New Orleans					105	331	132,820	418,720	550	1,700	1,800	580	440
Average					108	269	136,425	340,514	560	1,400	1,800	710	510
VI. Laurentian Basin:[a]													
United States area	175,000				116	1	20,360	181	600	5	1,700	200,000	1,600
1. Lake Superior	76,100			1.02	60	1							
United States area	48,600				60	1	2,920	49	310	5	3,200	200,000	3,100
Saulte Ste. Marie, Mich	76,100	60	Trace.										
2. Lakes Michigan-Huron	137,900			.874									
United States area	71,300				126	.8	8,950	50	660	4	1,500	250,000	1,500
3. Lakes Superior-Michigan-Huron	213,900			.924	99	.9							
United States area	119,900				99	.9	11,870	108	520	5	1,900	200,000	1,900
Chicago, Ill. (drainage canal)	213,900	130	Trace.	.022	3	.0							
Port Huron, Mich. (St. Clair River)	213,900	108	Trace.	.902	96	.9							
4. Lake Erie	40,800			.539									
United States area	23,400				184	.5	4,310	11	960	3	1,000	330,000	1,000
5. Lakes Superior-Michigan-Huron-Erie	254,700			.863	113	.8							
United States area	143,300				113	.8	16,180	119	590	4	1,700	250,000	1,700
Chicago, Ill. (drainage canal)	254,700	130	Trace.	.018	2.3	.0							

Buffalo, N. Y. (Niagara River and New York canals)	254,700	133	Trace.	.845	111	.8							
6. Lake Ontario	33,000			1.04									
United States area	18,000				144	1	2,600	18	750	5	1,300	200,000	1,300
7. Lakes Superior-Michigan-Huron-Erie-Ontario	287,700			.884	116	.9							
United States area	161,300				116	.9	18,780	137	600	5	1,700	200,000	1,600
Chicago, Ill. (drainage canal)	287,700	130	Trace.	.016	2.1	.0							
Buffalo, N. Y. (New York canals)	287,700	133	Trace.	.008	1.1	.0							
Ogdensburg, N. Y. (St. Lawrence River)	287,700	134	Trace.	.859	113	.9							
8. St. Lawrence River (below Ogdensburg, N. Y.)—													
United States area	13,660				116	3.2	1,580	44	600	17	1,700	50,000	1,600
Oswegatchie River—Ogdensburg, N. Y	1,580	77	10.0	1.72	130	17							
Lake Champlain	7,900	66	Trace.		113	1.7							
Rouses Point, N. Y	7,750			1.74									
VII. Colorado River:													
United States area	230,000				51	387	11,730	89,010	270	2,000	3,800	500	440
Yuma, Ariz	225,000	710	5,354.0	.0733	51	387							
1. Gila	71,100				80	[b] 225	5,600	16,000	420	1,200	2,400	860	630
Salt River	13,000				150	235							
Roosevelt, Ariz	5,760	646	1,300.0	.238	151	304							
McDowell, Ariz. (Verde River)	6,000	363	1,137.0	.141	50	158							
Mesa, Ariz	12,260	1,000	1,274.0	.189	203	237							
Gila River					13	210							
San Carlos, Ariz	13,500	[illegible]	4,682.0	.015	12	69							
Florence, Ariz	17,850	944	14,130.0	.015	14	209							
2. Little Colorado	31,000				11	134	340	4,150	57	700	18,000	1,400	1,300
Woodruff, Ariz	6,000	602	7,149.0	.019	11	134							
3. Grand	26,200				198	470	5,190	12,310	1,000	2,400	970	410	[b] 290
Palisades, Colo	8,550	[c] 429	[c] 1,358.0	.546	230	730							
Whitewater, Colo. (Gunnison River)	7,870	484	553.0	.350	167	190							
4. Green	41,000				90	165	3,600	6,760	470	800	2,100	1,200	750
Jensen, Utah	26,600	369	679.0	.247	90	165							
VIII. Southern Pacific	72,700				177	75	12,850	5,460	920	380	1,100	2,600	760
1. Minor Southern Pacific	22,800			.325	196	71	4,470	1,620	1,000	370	980	2,700	720
Soledad, Cal. (Arroyo Seco)	215	284	33.0	.793	222	26							
Santa Maria, Cal. (Santa Maria River)	1,000	2,412	1,302.0		204	110							
Santa Barbara, Cal. (Santa Ynez River)	207	714	64.0	.495	348	31							

[a] Figures are based upon assumption that unit denudation above Ogdensburg is the same for the United States and Canada.

[b] Suspended matter probably far too low.

[c] Analyses cover only portion of year. Results appear too high for an average.

Detailed estimates—Continued.

Drainage basin.	Physical and chemical data.				Estimated denudation.								
	Area (square miles).	Solids (parts per million).		Run-off (second-feet per square mile).	Tons of solids per square mile per year.		Thousand tons of solids per year.		Millionths of an inch per year.		Years required for 1 inch.		
		Dis-solved.	Sus-pended.		Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Dis-solved.	Sus-pended.	Total.
VIII. Southern Pacific—Continued.													
1. Minor Southern Pacific—Continued.													
Calabasas, Cal. (Malibu Creek)	97	717	61.0	.375	265	23							
Mentone, Cal. (Santa Ana River)	182	139	53.0	.409	56	21							
Pala, Cal. (San Luis Rey)	318	321	142.0	.352	111	49							
2. San Francisco Bay	49,900				168	77	8,380	3,840	880	400	1,100	2,500	780
Sacramento River	31,400			1.45	172	86							
Sacramento, Cal	29,500	121	60.0	1.45	172	86							
San Joaquin River[a]	16,500			1.02	162	60							
Lathrop, Cal	12,500	161	60.0	1.02	162	60							
IX. Northern Pacific	[b] 270,000				100	20	27,000	5,400	520	100	1,900	9,600	1,600
X. Great Basin	[b] 223,000				90	50	20,070	11,150	470	260	2,100	3,800	1,400
XI. Hudson Bay (in United States)	62,000				28	21	1,740	1,300	150	110	6,800	9,100	3,900
Red River of the North—													
Total area in United States	50,000				28	21	1,400	1,050	150	110	6,800	9,100	3,900
Grand Forks, N. Dak	25,000	[c] 200	[c] 150.0	.141	28	21							

[a] Excluding Tulare Lake.

[b] Analytical data extremely meager.

[c] Estimated from four analyses.

DEVELOPED WATER POWERS.

Compiled by the Bureau of the Census, under the direction of W. M. STEUART, Chief Statistician for Manufactures.

Discussion by M. O. LEIGHTON, Chief Hydrographer, U. S. Geological Survey.

A special census of the developed water powers of the United States has been made by the Bureau of the Census for the specific purposes of the conservation report. Previous inquiries of the same kind, made by this bureau, afforded a record of the names and locations of practically all the water-power developments that had taken place up to the dates thereof, and this record was used as the basis for the new census. Information concerning the developments that have been made since the date of the last census was procured through the Geological Survey, Forest Service, Bureau of Corporations, Post-Office Department, and many other agencies, both state and national. Special inquiry blanks were sent to all, including those that had figured in past censuses.

In making the new census it was necessary to procure the data in large measure by mail, and therefore it was necessary to simplify the inquiry and to secure only the facts absolutely necessary to a comprehensive summary of the developed water powers. The inquiry blank used for this purpose is reproduced below:

[Return this card to the Department of Commerce and Labor, Bureau of the Census, Washington, D. C.]

WATER POWER, 1908.

This office is engaged in the preparation of a report on the developed and undeveloped water power of the United States. If you use water power, please answer the following inquiries. If you do not use water power, please so state, and give the names and addresses of any power plants in your neighborhood. The card should be returned in the inclosed official envelope.

Name ------------------------------
Post-office ---------------------- State ----------
Location of plant: County ---------------- State ----------
Name of river or stream on which plant is located ----------
Number of water wheels ---------- Maximum horsepower ----------
Horsepower actually developed during low-water season ----------
Additional power that may be developed at same point on the same river or stream, horsepower ----------
Auxiliary steam power used in same plant, horsepower ----------
Character of industry ------------------------------
(Give name of principal product.)
Give names and addresses of other power plants in your neighborhood ----------

The character of the returns and the proportion of replies received indicate that the census is fairly complete. It is known that a greater number of the plants not accounted for in this census are of small capacity. There is, of course, some deficiency in the total; but it is believed that this is compensated by the general tendency among water-power owners to return statements based on actual wheel capacity installed rather than actual minimum power developed during the extreme low-water season. In all wheel installation it is the practice to develop above the minimum flow, and it follows that in the majority of power plants there must be a tendency to overstate the power actually developed during the lowest water. The final figures represent what is believed by those most conversant with the situation to be a reasonably accurate summary of the water power now developed in the country.

The material procured from the census has been arranged by drainage areas and combined into grand divisions, according to the plan followed in the report on undeveloped water power.

Accompanying Table No. 1 gives a general summary of the horsepower developed in the United States and the number of wheels used for such development. It will be noted that this table gives results according to States as well as according to grand divisions.

Some interesting facts are shown. The total development in the country is 5,356,680 horsepower over 52,827 wheels, or an average development per wheel of about 100 horsepower. In the Northern Atlantic division there has been a greater water-power development than in any other, the total installation being 1,746,303 horsepower. The only other division that approaches the Northern Atlantic in development is that covering the drainage area of the St. Lawrence, including the Great Lakes, where there has been a development of 1,018,283 horsepower. The great power development in the Northern Atlantic division may largely be explained by the fact that the use of water power therein began at an earlier period than in any other divison. New England and the Middle Atlantic States are and have been essentially manufacturing in character, and water-power development has followed as a matter of course. It is also true that the presence of good powers in large numbers in this region has encouraged such development.

Comparisons of wheel capacities installed in various parts of the country are interesting. While the total figures show that the average power per wheel is 100 horsepower, the units in the various districts vary as follows:

Division.	Unit capacity horsepower per wheel.	Division.	Unit capacity horsepower per wheel.
Northern Atlantic	80	St. Lawrence	14
Southern Atlantic	77	Colorado River	[illegible]
Eastern Gulf of Mexico	42	Southern Pacific	[illegible]
Western Gulf of Mexico	47	Northern Pacific	[illegible]
Eastern Mississippi	60	Interior drainage	[illegible]
Western Mississippi	139	Arctic Ocean	[illegible]

The large number and small unit capacity of wheels in the eastern part of the country compared with the smaller number and larger capacity in the western portions, including, especially, the rivers draining from the Rocky Mountains and the Sierras, may be explained: First, by the fact that in the eastern and central portions of the country the power privileges are of smaller capacity; and second, by the fact that in the eastern portions of the country a large number of the powers were installed at an early date, when it was the rule to establish small units. More recent practice has involved the establishment of larger units, and as the western installations are all recent, this practice, taken together with the existence of larger power privileges, gives the result that might be expected from a general survey of the situation.

Table 1 shows that New York State has the largest water-power development, the total being 885,862 horsepower. It is proper to add that the Niagara powers on the New York side assist largely in making up this figure. The second State in water-power development is California, the total being 466,774 horsepower, over 1,070 wheels, or a unit installation of about 436 horsepower. Water-power development in California is comparatively recent. The third State is Maine, with 343,096 horsepower, over 2,797 wheels, or an average of 123 horsepower per wheel. As the use of water power in this State is comparatively ancient, the contrast in unit capacity between it and California is significant.

Among the other interesting points is the fact that, although, as shown by the report on undeveloped water power, the Northern Pacific division can be made to furnish about one-third of the total minimum horsepower of the country, there is at the present time a development of only 450,000 horsepower, which indicates clearly that the most fertile field for power development remaining in the United States is this northwestern country.

Table 2 gives the installations by districts and drainage areas, special comment concerning which is unnecessary.

Census returns show that, out of a total of 31,537 powers reported, 602 are of capacity of 1,000 horsepower or more. Recent progress in water-power development has been marked by great installations. In former years the aggregate water power utilized in the country was made up largely of small units, which, while useful for local purposes and worthy of development, are not relatively important in the great question of power economics. The following summary gives the distribution of the powers of 1,000 horsepower and greater capacity, and it shows clearly that what was formerly believed to be an uncommonly great installation must now be considered a comparatively small feature.

Capacity distribution of powers of 1,000 horsepower and more.

1,000 to 5,000	459
5,000 to 10,000	65
10,000 to 15,000	27
15,000 to 20,000	13
20,000 to 25,000	17
25,000 to 40,000	11
40,000 to 60,000	4
60,000 to 100,000	3
100,000 and over	3
Total	602

Number of water powers by States and Territories, 1908.

United States	31,537
Alabama	1,382
Alaska	31
Arizona	29
Arkansas	203
California	550
Colorado	230
Connecticut	893
Delaware	119
District of Columbia	1
Florida	166
Georgia	1,596
Idaho	199
Illinois	155
Indiana	222
Iowa	207
Kansas	118
Kentucky	691
Louisiana	64
Maine	1,222
Maryland	496
Massachusetts	1,370
Michigan	657
Minnesota	195
Mississippi	273
Missouri	277
Montana	94
Nebraska	157
Nevada	32
New Hampshire	876
New Jersey	560
New Mexico	48
New York	3,148
North Carolina	2,614
North Dakota	9
Ohio	480
Oklahoma	25
Oregon	345
Pennsylvania	3,721
Rhode Island	191
South Carolina	846
South Dakota	45
Tennessee	1,793
Texas	147
Utah	200
Vermont	1,148
Virginia	2,243
Washington	322
West Virginia	525
Wisconsin	580
Wyoming	33

TABLE 1.—*General summary—Drainage basins by States.*

States.	Northern Atlantic.		Southern Atlantic.		Gulf of Mexico.				Mississippi River.			
					Eastern.		Western.		Tributaries from the east.		Tributaries from the west.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
United States	21,864	1,746,303	5,938	459,652	3,342	139,758	258	12,071	8,959	537,080	2,385	331,739
Alabama					1,539	56,603			265	105,091		
Alaska												
Arizona												
Arkansas											255	5,868
California												
Colorado							13	937			146	26,279
Connecticut	1,546	118,145										
Delaware	277	7,976										
District of Columbia	6	1,000										
Florida			13	420	194	4,119						
Georgia			854	90,036	1,307	74,255			153	2,296		
Idaho												
Illinois									413	50,116		
Indiana									298	11,525		
Iowa											461	17,304
Kansas											184	18,600
Kentucky									834	14,156		
Louisiana					35	615	22	296			22	273
Maine	2,797	343,096										
Maryland	679	21,403							15	312		
Massachusetts	2,740	200,182										
Michigan												
Minnesota									100	15,925	361	82,007
Mississippi					207	4,166			60	3,756		
Missouri											397	10,107
Montana											102	140,494
Nebraska											227	12,792
Nevada												
New Hampshire	1,799	183,167										
New Jersey	902	38,011										
New Mexico							32	939			13	251
New York	3,046	304,003							87	3,167		
North Carolina			3,040	140,918					926	21,366		
North Dakota												
Ohio									682	26,291		

TABLE 1.—*General summary—Drainage basins by States*—Continued.

States.	Northern Atlantic.		Southern Atlantic.		Gulf of Mexico.				Mississippi River.			
					Eastern.		Western.		Tributaries from the east.		Tributaries from the west.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
Oklahoma											29	2,994
Oregon												
Pennsylvania	5,046	273,426							530	16,840		
Rhode Island	387	37,165										
South Carolina			1,301	207,242								
South Dakota											68	11,112
Tennessee									2,160	95,060		
Texas							190	9,890			5	67
Utah												
Vermont	1,047	90,672										
Virginia	1,440	59,129	721	21,036					850	19,938		
Washington												
West Virginia	143	8,928							529	11,572		
Wisconsin									1,048	139,640		
Wyoming											55	3,585

States.	St. Lawrence River.		Colorado River.		Southern Pacific.		Northern Pacific.		Interior drainage.		Arctic Ocean.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
United States	6,896	1,018,283	285	74,428	822	423,707	1,659	[a] 489,454	353	115,944	66	8,261	52,827	5,356,680
Alabama													1,804	161,604
Alaska							106	17,280					106	17,280
Arizona			37	16,855									37	16,855
Arkansas													255	5,868
California					820	423,507	176	25,440	74	17,737			1,070	466,774
Colorado			194	51,662									353	78,878
Connecticut													1,546	118,145
Delaware													277	7,976

District of Columbia													6	1,000
Florida													207	4,530
Georgia													2,314	106,587
Idaho							261	60,533	24	18,210			285	78,743
Illinois													413	50,116
Indiana	197	17,628											495	29,153
Iowa													461	17,304
Kansas													184	18,606
Kentucky													834	14,156
Louisiana													79	1,184
Maine													2,797	343,096
Maryland													694	21,715
Massachusetts													2,749	260,182
Michigan	1,498	205,019											1,498	205,019
Minnesota	20	46,800									50	7,648	531	152,380
Mississippi													336	7,922
Missouri													397	10,107
Montana							42	7,558					204	148,052
Nebraska													227	12,792
Nevada			1	3			7	252	31	20,322			39	20,577
New Hampshire													1,799	183,167
New Jersey													902	38,011
New Mexico			10	1,120									56	2,310
New York	3,380	578,092											6,513	885,862
North Carolina													3,975	162,284
North Dakota											16	613	16	613
Ohio	191	8,540											873	34,840
Oklahoma													29	2,994
Oregon					2	110	586	231,203	2	66			590	231,379
Pennsylvania	20	715											5,596	290,990
Rhode Island													387	37,165
South Carolina													1,301	207,242
South Dakota													68	11,112
Tennessee													2,160	95,060
Texas													195	9,966
Utah			38	4,656					222	59,609			260	64,265
Vermont	971	79,604											2,018	170,276
Virginia													3,011	100,123
Washington							475	147,041					475	147,041
West Virginia													672	20,500
Wisconsin	619	81,276											1,667	220,916
Wyoming			5	132			6	138					66	3,855

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[a] Includes Alaska.

TABLE 2.—*Drainage basins in the United States.*

I. NORTHERN ATLANTIC.

Drainage basins.	Maine.		New Hampshire.		Vermont.		Massachusetts.		Connecticut.		Rhode Island.		New York.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	2,797	343,096	1,799	183,167	1,047	90,672	2,749	260,182	1,546	118,145	387	37,165	3,046	304,003
St. Johns River	147	13,681												
St. Croix River	89	20,500												
Penobscot River	518	70,454												
Kennebec River	650	63,936												
Androscoggin River	590	101,355	93	22,100										
Presumpscot River	179	20,569												
Saco River	169	22,302	68	3,030										
Merrimac River			877	90,082			589	71,251						
Connecticut River			574	50,977	929	85,512	1,117	123,309	490	33,101				
Blackstone River							182	14,111			156	17,324		
Thames River							88	8,499	478	45,214	1	25		
Housatonic River							138	14,206	364	31,685			17	459
Hudson River					118	5,160	54	5,245					2,083	275,125
Passaic River													30	775
Raritan River														
Delaware River													208	5,924
Susquehanna River													645	20,187
Potomac River														
James River														
Minor streams (Chesapeake Bay)														
Minor streams (northern Atlantic)	446	30,299	187	16,978			581	23,561	214	8,145	230	19,816	63	1,533

Drainage basins.	New Jersey.		Delaware.		Pennsylvania.		Maryland.		Virginia.		West Virginia.		District of Columbia.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	902	38,011	277	7,976	5,046	273,426	679	21,403	1,440	59,129	143	8,928	6	1,000	21,864	1,746,303
St. Johns River															147	13,681
St. Croix River															80	20,500
Penobscot River															518	70,454
Kennebec River															659	63,936
Androscoggin River															683	123,455
Presumpscot River															179	20,569
Saco River															237	25,332
Merrimac River															1,466	161,333
Connecticut River															3,110	292,890
Blackstone River															338	31,435
Thames River															567	53,738
Housatonic River															519	46,350
Hudson River	17	680													2,272	286,210
Passaic River	179	12,805													209	13,580
Raritan River	204	6,309													204	6,309
Delaware River	427	15,327	167	5,314	1,616	47,649									2,418	74,214
Susquehanna River					3,233	222,530	71	2,217							3,949	244,934
Potomac River					197	3,247	260	4,766	462	11,457	142	8,920	6	1,000	1,067	29,390
James River									607	40,165	1	8			608	40,173
Minor streams (Chesapeake Bay)			35	901			346	14,389	363	7,429					744	22,719
Minor streams (northern Atlantic)	75	2,890	75	1,761			2	31	8	78					1,881	105,092

TABLE 2.—*Drainage basins in the United States*—Continued.

II. SOUTHERN ATLANTIC.

Drainage basins.	Virginia.		South Carolina.		North Carolina.		Georgia.		Florida.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	721	21,036	1,301	207,242	3,049	140,918	854	90,036	13	420	5,938	459,652
Chowan River	113	2,381			64	1,147					177	3,528
Roanoke River	607	18,647			198	17,419					805	36,066
Tar River					166	6,431					166	6,431
Neuse River					317	11,365					317	11,365
Cape Fear River					673	27,539					673	27,539
Pedee (Yadkin) River			228	7,867	1,124	50,432					1,352	58,299
Santee River			573	179,708	478	26,028					1,051	205,736
Savannah River			294	16,178			245	43,357			539	59,535
Ogeechee River							88	1,965			88	1,965
Altamaha River							506	44,531			506	44,531
Minor streams (southern Atlantic)	1	8	206	3,489	29	557	15	183	13	420	264	4,657

III. EASTERN GULF OF MEXICO.

Drainage basins.	Florida.		Georgia.		Alabama.		Mississippi.		Louisiana.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	194	4,119	1,307	74,255	1,539	56,603	267	4,166	35	615	3,342	139,758
Suwanee River	16	265	29	962							45	1,227
Apalachicola River	36	565	784	62,991	114	7,717					934	71,273
Mobile River:												
Tombigbee River					340	5,193	79	1,097			419	6,290
Alabama River			464	9,869	799	37,892					1,263	47,761
Pearl River							86	1,532	18	312	104	1,844
Minor streams (eastern Gulf of Mexico)	142	3,289	30	433	286	5,801	102	1,537	17	303	577	11,363

IV. WESTERN GULF OF MEXICO.

Drainage basins.	Louisiana.		Texas.		New Mexico.		Colorado.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	22	296	190	9,899	33	939	13	937	258	12,071
Sabine River	11	126	24	263					35	389
Neches River			35	538					35	538
Trinity River			12	279					12	279
Brazos River			13	448					13	448
Colorado River (of Texas)			25	1,503					25	1,503
Guadalupe River			69	6,447					69	6,447
San Antonio River			6	215					6	215
Nueces River			3	36					3	36
Rio Grande			1	102	16	370	13	937	30	1,409
Pecos River			2	68	17	569			19	637
Minor streams (western Gulf of Mexico)	11	170							11	170

TABLE 2.—*Drainage basins in the United States*—Continued.

V. MISSISSIPPI RIVER (TRIBUTARIES FROM EAST).

Drainage basins.	Mississippi.		Alabama.		Georgia.		Tennessee.		North Carolina.		Virginia.		West Virginia.		Kentucky.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	69	3,756	265	105,091	153	2,296	2,160	95,060	926	21,366	850	19,958	529	11,572	834	14,156
Yazoo River																
Minor eastern tributaries, lower Mississippi River	61	709					62	796							4	67
Ohio River:																
Tennessee River	8	3,047	265	105,091	153	2,296	1,691	85,548	710	19,200	378	6,214			8	103
Cumberland River							397	8,576							284	4,431
Green River							10	140							205	3,634
Kentucky River															158	2,916
Licking River															52	928
Big Sandy River											20	261	20	320	91	924
Kanawha River									216	2,106	452	13,483	282	7,023		
Monongahela River													129	2,324		
Youghiogheny River													3	50		
Minor southern tributaries													95	1,855	32	1,153
Allegheny River																
Beaver River																
Muskingum River																
Scioto River																
Great Miami River																
Wabash River																
Minor northern tributaries																
Illinois River																
Rock River																
Wisconsin River																
Chippewa River																
St. Croix River																
Minor eastern tributaries, upper Mississippi River																

Drainage basins.	Pennsylvania.		Ohio.		Indiana.		Illinois.		Wisconsin.		Minnesota.		New York.		Maryland.		Total for drainage basins.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	530	16,849	682	26,291	298	11,525	413	50,116	1,048	139,640	100	15,925	87	3,167	15	312	8,950	537,080
Yazoo River	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Minor eastern tributaries, lower Mississippi River	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	127	1,572
Ohio River:																		
Tennessee River	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	3,213	221,550
Cumberland River	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	681	13,007
Green River	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	215	3,774
Kentucky River	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	158	2,916
Licking River	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	52	928
Big Sandy River	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	131	1,505
Kanawha River	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	950	22,612
Monongahela River	18	262	......	......	......	......	......	......	......	......	......	......	......	......	......	......	147	2,586
Youghiogheny River	56	1,205	......	......	......	......	......	......	......	......	......	......	......	......	15	312	74	1,567
Minor southern tributaries	3	70	......	......	......	......	......	......	......	......	......	......	......	......	......	......	130	3,078
Allegheny River	331	8,146	......	......	......	......	......	......	......	......	......	......	87	3,167	......	......	418	11,313
Beaver River	121	7,154	44	2,320	......	......	......	......	......	......	......	......	......	......	......	......	165	9,474
Muskingum River	......	......	204	8,880	......	......	......	......	......	......	......	......	......	......	......	......	204	8,880
Scioto River	......	......	69	2,045	......	......	......	......	......	......	......	......	......	......	......	......	69	2,045
Great Miami River	......	......	187	8,245	27	1,224	......	......	......	......	......	......	......	......	......	......	214	9,469
Wabash River	......	......	......	......	238	9,993	4	72	......	......	......	......	......	......	......	......	242	9,665
Minor northern tributaries	1	12	178	4,801	24	465	6	118	......	......	......	......	......	......	......	......	209	5,396
Illinois River	......	......	......	......	9	243	222	36,162	29	803	......	......	......	......	......	......	260	37,298
Rock River	......	......	......	......	......	......	167	13,214	210	10,967	......	......	......	......	......	......	377	24,181
Wisconsin River	......	......	......	......	......	......	......	......	476	74,491	......	......	......	......	......	......	476	74,491
Chippewa River	......	......	......	......	......	......	......	......	157	24,976	......	......	......	......	......	......	157	24,976
St. Croix River	......	......	......	......	......	......	......	......	58	11,025	13	1,750	......	......	......	......	71	12,775
Minor eastern tributaries, upper Mississippi River	......	......	......	......	......	......	14	550	118	17,288	87	14,175	......	......	......	......	219	32,013

TABLE 2.—*Drainage basins in the United States*—Continued.

VI. MISSISSIPPI RIVER (TRIBUTARIES FROM THE WEST).

Drainage basins.	Louisiana.		Arkansas.		Texas.		Oklahoma.		New Mexico.		Colorado.		Kansas.		Missouri.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	22	273	255	5,868	5	67	29	2,994	13	251	146	26,279	184	18,606	397	10,107
Minnesota River																
Wapsipinicon River																
Des Moines River																
Missouri River:																
Big Sioux River																
James River																
Milk River																
Marias River																
Jefferson River																
Madison River																
Gallatin River																
Minor northern tributaries															38	938
Musselshell River																
Yellowstone River																
Little Missouri River																
Cheyenne River																
White River																
Niobrara River																
Platte River											126	21,803				
Kansas River											1	75	122	10,192		
Osage River													1	18	71	1,448
Minor southern tributaries													1	15	31	502
Arkansas River			74	1,100							19	4,401	22	1,205	194	5,874
Cimarron River:																
Canadian River							7	291	13	251						
Minor tributaries			108	3,797			4	160					38	7,176		
Red River	22	273	73	971	5	67	18	2,543								
Minor western tributaries Mississippi River															63	1,345

Drainage basins.	Iowa.		Nebraska.		Wyoming.		Montana.		South Dakota.		Minnesota.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	461	17,304	227	12,792	55	3,585	162	140,494	68	11,112	361	82,007	2,385	331,739
Minnesota River											40	1,712	40	1,712
Wapsipinicon River	54	1,655											54	1,655
Des Moines River	27	1,360									3	198	30	1,558
Missouri River:														
Big Sioux River	8	261							15	3,115			23	3,376
James River									20	411			20	411
Milk River														
Marias River														
Jefferson River							38	20,619					38	20,619
Madison River							13	17,336					13	17,336
Gallatin River							6	405					6	405
Minor northern tributaries	62	2,274					44	67,215	11	231			155	70,658
Musselshell River														
Yellowstone River					19	1,389	26	6,224					45	7,613
Little Missouri River														
Cheyenne River					20	331			22	7,355			42	7,686
White River			1	30									1	30
Niobrara River			30	950									30	950
Platte River			74	5,572	16	1,865							216	29,240
Kansas River			89	5,156									212	15,423
Osage River													72	1,466
Minor southern tributaries			33	1,084			35	28,695					100	30,296
Arkansas River													309	12,580
Cimarron River:														
Canadian River													20	542
Minor tributaries													150	11,133
Red River													118	3,854
Minor western tributaries Mississippi River	310	11,754									318	80,097	691	93,196

TABLE 2.—*Drainage basins in the United States*—Continued.

VII. ST. LAWRENCE RIVER.

Drainage basins.	Minnesota.		Wisconsin.		Michigan.		Indiana.		Ohio.		Pennsylvania.		New York.		Vermont.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	20	46,800	619	81,276	1,498	205,019	197	17,628	191	8,549	20	715	3,380	578,692	971	79,604	6,896	1,018,283
Lake Superior	20	46,800	6	2,227	73	34,775											99	83,802
Lake Michigan			613	79,049	963	145,179	172	16,463									1,748	240,691
Lake Huron					213	13,878											213	13,878
St. Clair River					85	3,331											85	3,331
Lake Erie					164	7,856	25	1,165	191	8,549	17	593	120	4,838			526	23,001
Niagara River													103	101,426			103	101,426
Lake Ontario											3	122	2,025	209,368			2,028	209,490
Lake Champlain (Richelieu River)													373	50,345	971	79,604	1,344	129,949
Minor St. Lawrence tributaries													750	122,715			750	122,715

VIII. COLORADO RIVER.

Drainage basins.	Arizona.		New Mexico.		Colorado.		Wyoming.		Utah.		Nevada.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	37	16,855	10	1,120	194	51,662	5	132	38	4,656	1	3	285	74,428
Gila River	26	16,611	7	995									33	17,606
Williams River	1	9											1	9
Little Colorado River	8	185											8	185
San Juan River			3	125	45	18,260							48	18,385
Grand River					145	32,132			1	6			146	32,138
Green River					4	1,270	5	132	17	3,378			26	4,781
Fremont River									4	93			4	90
Virgin River									9	188	1	3	10	193
Minor tributaries	2	50							7	991			9	1,041

IX. SOUTHERN PACIFIC.

Drainage basins.	California.		Oregon.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	820	423,597	2	110	822	423,707
Minor streams	74	50,183			74	50,183
San Francisco Bay	11	6,455			11	6,455
Sacramento River	576	280,735	2	110	578	280,845
San Joaquin River	159	86,224			159	86,224

X. NORTHERN PACIFIC.

Drainage basins.	Oregon.		Idaho.		Wyoming.		Montana.		Washington.		California.		Nevada.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	586	231,203	261	60,533	6	138	42	7,558	475	147,041	176	25,440	7	252	a 1,553	a 472,165
Columbia River:																
Willamette River	299	92,531													299	92,531
Des Chutes River	17	60,832													17	60,832
John Day River	24	22,083													24	22,083
Snake River	55	35,771	186	36,402	6	138			28	4,728			7	252	282	77,291
Spokane River			70	23,176					33	14,473					103	37,649
Pend Oreille (Clark Fork)			2	600			37	6,838	7	237					46	7,675
Yakima River									52	8,838					52	8,838
Minor tributaries	55	10,176							186	33,099					241	43,275
Kootenai River			3	355			5	720							8	1,075
Puget Sound									139	84,270					139	84,270
Minor streams, northern Pacific	136	9,810							30	1,396	176	25,440			342	36,646

a Exclusive of Alaska, with 106 wheels, of 17,289 horsepower.

TABLE 2.—*Drainage basins in the United States*—Continued.

XI. GREAT BASIN.

Drainage basins.	Utah.		Nevada.		California.		Oregon.		Idaho.		Total.	
	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.	Wheels.	Horse-power.
	222	59,609	31	270,322	74	17,737	2	66	24	18,210	353	115,944
Wasatch Mountains drainage	222	59,609							24	18,210	246	77,819
Humboldt River			31	20,322			2	66			33	20,388
Sierra Nevada drainage					74	17,737					74	17,737
Minor streams in Great Basin												

XII. HUDSON BAY.

Drainage basins.	North Dakota.		Minnesota.		Total.	
	Wheels.	Horsepower.	Wheels.	Horsepower.	Wheels.	Horsepower.
	16	613	50	7,648	66	8,261
Red River of the North	16	613	50	7,648	66	8,261
St. Marys River						

UNDEVELOPED WATER POWERS.

By M. O. Leighton,
Chief Hydrographer, United States Geological Survey.

The surveys and examinations necessary to a thorough and accurate report of the water-power resources of the United States have never been completed. In certain parts of the country the facts are sufficiently well known to make it possible to present a tolerably accurate statement. In other parts the information is fragmentary, and therefore power estimates must be considered approximate. Taken as a whole, however, the schedule here appended will be sufficient for the purposes for which it was prepared.

In order to present the information in a systematic way, the drainage areas of the United States have been united into groups according to geographic distribution. These group boundaries have been arbitrarily determined according to what seems to be the most convenient arrangement for the purposes of this report. The grouping is as follows: Atlantic Ocean, Pacific Ocean, Arctic Ocean, and interior drainage. These groups have been subdivided into 12 principal divisions, as follows: I. Northern Atlantic; II. Southern Atlantic; III. Eastern Gulf of Mexico; IV. Western Gulf of Mexico; V. Mississippi River (tributaries from the east); VI. Mississippi River (tributaries from the west); VII. St. Lawrence; VIII. Colorado River; IX. Southern Pacific; X. Northern Pacific; XI. Great Basin; XII. Hudson Bay.

SOURCES OF DATA.

The data used in this report have been obtained from the following sources:

The records of flow are mainly from the reports and files of the water-resources branch of the United States Geological Survey. As the period over which these records extend varies in length, a seven-year period, extending from 1900 to 1906, inclusive, was taken as a basis and all values of flow are the mean for these years.

The profiles and elevations have been obtained as follows:

(*a*) River surveys made by the United States Geological Survey, U. S. Army Engineer Corps, and others.

(*b*) Elevations as given by railroad and other levels.

(*c*) Dictionary of Altitudes, Bulletin No. 274, United States Geological Survey.

(*d*) United States Geological Survey topographic maps.

(*e*) Miscellaneous maps and reports of various State and other organizations.

In the use of maps the following preferences have been given: (1) United States Geological Survey topographic sheets; (2) special detailed surveys; (3) General Land Office maps; (4) United States post-route maps; (5) Rand & McNally Atlas sheets

WATER POWER.

The schedule presented in this report gives the amount of available water power according to three classifications—(1) that which may be produced by the minimum flow; (2) the assumed maximum development; and (3) the additional power that may be recovered by developing the available storage capacity in the upland basins and using stored water to compensate the low-water periods. The data as a whole have been considered without reference to present practicability of development or present market. For the purposes of this report it has been assumed that all the power in the United States will some day be required. Such an interpretation is the logical one when natural resources are being considered. In other words, the schedule here presented must be interpreted for the future rather than for the present. The reader should not assume that all the power here shown is economically available to-day. Much of it, indeed, would be too costly in development to render it of commercial importance under the present conditions of market and the price of fuel power. The schedule shows therefore what will be the maximum possibilities in the day when our fuel shall have become so exhausted that the price thereof for production of power is prohibitive, and the people of the country shall be driven to the use of all the water power that can reasonably be produced by the streams.

Consideration has been given to all the conditions that determine the possibilities of power production on the various rivers of the country. Especially has the slope of the stream channels been scrutinized. Theoretically, of course, the energy developed by the various rivers is that produced by the total fall of the water from source to mouth, but it has not been assumed that, even under ideal conditions of market, all this power will ever be commercially available. The flatter portions of the river channels can never be profitably developed for power and they have not been included in the schedule. The rivers have been divided into sections of varying length, determined by channel slope, and the fall and flow of each section have been obtained from the best available sources of information. The records of stream flow collected by the water-resources branch of the Geological Survey have almost uniformly been the only available resort, although acknowledgments should be made to the state water-supply commissions of New York and Pennsylvania; the state engineers of New York, Colorado, California, Oregon, and Nebraska; the territorial engineer of New Mexico; the state geological surveys of Maine, New Jersey, North Carolina, Virginia, Georgia, and Wisconsin; and various other bodies and individuals, public and private, who in the past have maintained measurements in cooperation with the United States Geological Survey or independently. Use has also been made of certain river gage records of the United States Weather Bureau and of the Corps of Engineers, U. S. Army.

In determining the flow for the various sections the data of flow per square mile, procured from the sources above enumerated, have been applied. The drainage areas above the upper and the lower limits of each section have been determined and a mean taken for the whole section. This has been used as a factor along with the flow per square mile in determining the minimum flow for that section. This figure, together with 90 per cent of the total fall from head to foot, has been used to determine theoretical horsepowers, according to the usual formulas. It is obvious that in practice the entire fall along any stretch of river or at any power privilege can not be effectively utilized. In few places can even 90 per cent be utilized at the present time; but, inasmuch as these figures are supposed to cover future as well as present practice, and inasmuch as it may reasonably be assumed that future practice in water-power installation will improve, it is believed that 90 per cent of the fall along any particular power privilege or section may eventually be realized.

The results of calculations of theoretical power on 90 per cent total fall have been reduced 10 per cent to allow for inefficiency of wheels. It is recognized that 90 per cent efficiency is too high to be used in calculations of power at the present time, 75 or 80 per cent being the usual installation maximum. Here again, however, we are computing for future conditions, as well as present ones, and it may confidently be expected that, with the improvement of turbines, a greater percentage of the theoretical power will be realized on the shaft and improvements will before long render possible a 90 per cent efficiency.

In determining the minimum horsepower, the minimum flow for the lowest two consecutive seven-day periods in each year was determined and the mean of these values for the period of record was taken as the minimum flow. It is obvious that this is somewhat higher than the absolute minimum, but the latter is usually of so short duration that it does not equal the practicable minimum that may profitably be installed.

The assumed maximum economical development has been determined on the assumption that it is good commercial practice to develop wheel installation up to that amount the continuance of which can be assured during six months of the year, on the assumption that the deficiency in power during the remainder of the year can be profitably provided by the installation of fuel power plants as auxiliaries. In many parts of the country it has been shown conclusively that it is economical to develop up to that amount which can be had continuously during the highest four months of the year, and, while it is probable that there are parts of the country where the limit should be the highest eight or ten months, it is believed that the period used in these schedules is a very conservative average. The minimum weekly flow for each month of the year has been arranged according to magnitude, and the sixth value has been taken as the basis for estimating the power, the mean of these values for the record period in each case being that used in the computations.

An endeavor has been made to determine the maximum power that might be produced if the practicable maximum storage available on the drainage areas were established. Surveys on many of the basins make possible a fairly close statement; but, inasmuch as fully three-fourths of the country has not been surveyed in a manner suitable for this purpose, only rough estimates can be given for the entire area. There are two methods by which an approximate estimate of total power can be made.

The first is to consider the power on those drainage areas for which suitable surveys are available and to increase the amount by the equivalent of the proportion left unsurveyed. An examination of the facts will show that the amount obtained by this method will be too low. It is apparent from a review of the index map showing the areas covered by such surveys that a fairly large proportion, probably one-third, comprises country in which good reservoir sites are either lacking or are uncommon in occurrence. Such portions include large parts of the Dakotas, Nebraska, Kansas, Oklahoma, Texas, and Louisiana, together with great areas on the Atlantic and Pacific coastal plains. Therefore to increase the total available water power from storage that may be computed on surveyed portions by the ratio of total surveyed portions to the entire country would hardly do justice to the situation. Nevertheless, the figures are here presented.

It is found that the total power available in the surveyed portions, including storage, is about 53,000,000 horsepower. If this be considered as one-fourth, to correspond with the portion of the country surveyed, the total power of the country, with practical maximum storage will be about 212,000,000 horsepower.

The second method of computation involves consideration of the increase of power available from storage in the several portions of the country in which surveys have been made, and applying the ratio of increase to unsurveyed and similar country in those regions. The topographic surveys, while they cover only one-fourth of the total area of the country, have nevertheless been prosecuted in all sections, so that the storage data are applicable to all physiographic types that are comprised within the United States. Applying the information in this way, we obtain a grand total of 230,800,000 horsepower, which, it appears to the writer, is a more accurate figure than that obtained by the first method.

In any case, therefore, it may be assumed with confidence that, were all practicable storage sites utilized and the water properly applied, there might be established eventually in the country a total power installation of at least 200,000,000 horsepower and probably much more.

In the actual management of storage for water power or for any other water utilization the stored waters are released according as needed, and they must be distributed according to the condition of the river and the length of the dry season. Therefore, water from storage is required for a varying number of months, according to the climatological conditions governing the river discharge. Some assumption in this matter has been necessary, and it is believed from the experience that has been gained in the study of rivers throughout the country that it will be fair and conservative to assume that, if any given storage be considered as released uniformly during six months of the year, and the natural flow from the unconserved areas be considered as sufficient to maintain at least an equal flow during the remaining six months, the results will not depart too widely from the actual conditions as regards total power that may be achieved in practice, unless, indeed, they are too conservative. It is well known that on some rivers an economical use of stored water would involve a shorter period of total release than six months to insure the most uniform distribution of discharge. This would provide for a greater power development than the six months of distribution. Nevertheless, the latter has been considered a fair average and has been used in the accompanying schedule.

Summing up the whole country according to the divisions thereof heretofore discussed, we obtain the general summary given below. Especial mention should be made of the fact that the results here given do not include the State of Pennsylvania, the figures for which had not been furnished up to the date of this report.

Estimate of stream flow and water power in the United States.

Principal drainages.	Drainage area in square miles.	Flow per annum in billion cubic feet.	Horsepower.	
			Minimum.	Assumed maximum development.
North Atlantic to Cape Henry, Va	159,879	8,942	1,712,050	[a]3,186,600
Southern Atlantic to Cape Sable, Fla	123,920	5,560	1,253,000	1,957,800
Eastern Gulf of Mexico to Mississippi River	142,220	6,867	559,000	963,000
Western Gulf of Mexico west of Vermilion River	[b]433,700	2,232	433,760	822,600
Mississippi River (tributaries from east)	333,600	12,360	2,619,590	[a]5,344,600
Mississippi River (tributaries from west, including Vermilion River)	905,200	9,580	3,948,970	7,085,000
St. Lawrence River to Canadian line	[c]299,720	8,583	6,682,480	8,090,000
Colorado River above Yuma, Ariz	225,000	521	2,918,500	5,546,000
Southern Pacific to Point Bonita, Cal	70,700	2,193	3,215,400	7,808,300
Northern Pacific	290,400	15,220	12,979,700	24,701,000
Great Basin	223,000	....	518,000	801,000
Hudson Bay	62,150	614	75,800	212,600
Total	3,269,490	72,672	36,916,250	66,518,500

[a] Not including area in Pennsylvania.
[b] Includes Rio Grande in Mexico.
[c] Includes drainage in Canada.

It will be noted from the foregoing that the region furnishing by far the greatest water-power possibilities is the northern Pacific, which comprises essentially the basins of Columbia and Sacramento rivers, the power possibilities there being about one-third those of the whole United States.

The following schedules give in detail figures concerning run-off and potential water power over the various drainage areas included within the several districts:

Estimate of stream flow and water power in the United States.

I. NORTHERN ATLANTIC.[a]

Stream.	States drained.	Drainage area (square miles).	Flow from area.				Horsepower.	
			Second-feet.	Second-feet per square mile.	Per annum.		Minimum.	Assumed maximum development.
					Depth in inches.	Billion cubic feet.		
St. Johns[b]	Maine	7,500	13,200	1.76	23.90	416	30,500	73,800
St. Croix	do	1,630	4,260	2.61	35.40	131	28,700	49,000
Penobscot	do	8,500	16,700	1.96	26.60	526	157,000	298,000
Kennebec	do	5,970	11,000	1.84	25.00	347	144,000	284,000
Androscoggin	Maine, New Hampshire	3,500	7,500	2.14	29.00	236	168,000	218,000
Presumpscot	Maine	600	1,010	1.68	22.80	32	(c)	(c)
Saco	Maine, New Hampshire	1,720	4,060	2.36	32.00	128	20,900	69,000
Merrimac	New Hampshire, Massachusetts	5,020	8,140	1.62	22.00	257	111,000	190,000
Connecticut	Vermont, New Hampshire, Massachusetts, Connecticut	11,100	22,100	1.99	27.00	697	230,000	491,000
Blackstone	Massachusetts, Rhode Island	(c)	....	(c)	(c)	(c)	5,280	12,700
Thames	Massachusetts, Connecticut, Rhode Island	(c)	....	(c)	(c)	(c)	14,400	28,600
Housatonic	New York, Massachusetts, Connecticut	1,980	4,300	2.17	29.40	136	43,100	66,200
Hudson	New York, Massachusetts, Vermont, New Jersey	13,400	25,400	1.90	25.80	802	298,000	473,000
Passaic	New York, New Jersey	949	2,060	2.17	29.40	65	10,000	22,000
Raritan	New Jersey	1,110	2,390	2.15	29.20	75	4,370	9,710
Delaware	New York, New Jersey, Pennsylvania, Delaware	13,100	25,800	1.97	26.70	814	....	....
Susquehanna	New York, Pennsylvania, Maryland	27,400	42,800	1.56	21.20	1,350	....	....
Potomac	Maryland, Virginia, West Virginia, Pennsylvania	14,300	17,300	1.21	16.40	545	176,000	462,000
James	Virginia	10,400	14,000	1.35	18.30	442	196,000	300,000
Minor streams (Chesapeake Bay)	Virginia, Maryland	12,800	20,300	1.59	21.60	640	43,300	82,000
Minor streams (northern Atlantic)	Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia.	18,900	41,200	2.18	29.60	1,300	31,500	57,600
Total	....	159,879	....	....	....	8,942	....	....

II. SOUTHERN ATLANTIC.[d]

Chowan	Virginia, North Carolina	5,000	7,000	1.40	19.00	221	5,100	10,100
Roanoke	do	9,740	12,200	1.25	17.00	385	205,000	343,000
Tar	North Carolina	4,360	5,500	1.26	17.10	174	4,000	8,000
Neuse	do	5,550	7,320	1.32	17.90	231	5,000	10,000
Cape Fear	do	9,030	11,100	1.23	16.70	350	40,000	80,000
Pedee (Yadkin)	North Carolina, South Carolina	10,600	16,900	1.60	21.70	533	222,000	334,000
Santee	do	14,800	24,500	1.66	22.50	772	400,000	590,000
Savannah	South Carolina, Georgia	11,100	17,500	1.58	21.40	552	290,000	438,000
Ogeechee	Georgia	5,140	6,530	1.27	17.20	206	4,300	10,700
Altamaha	do	14,100	17,700	1.26	17.10	558	57,600	94,000
Minor streams (southern Atlantic)	Virginia, North Carolina, South Carolina, Georgia, Florida	34,500	50,100	1.45	19.70	1,580	20,000	40,000
Total		123,920				5,560	1,253,000	1,957,800

III. EASTERN GULF OF MEXICO.[e]

Suwanee	Florida, Georgia	9,970	15,000	1.50	20.40	473	(f)	(f)
Apalachicola	Alabama, Georgia, Florida	18,800	30,300	1.61	21.80	956	204,000	326,000
Mobile	Alabama, Georgia, Mississippi	42,100	66,200	1.57	21.30	2,000		
Tombigbee	Alabama, Mississippi						50,000	100,000
Alabama	Alabama, Georgia						275,000	487,000
Pearl	Mississippi, Louisiana	8,650	12,300	1.42	19.30	388	(f)	(f)
Minor streams (eastern Gulf of Mexico)	Florida, Alabama, Mississippi, Louisiana	62,700	93,800	1.50	20.40	2,960	30,000	50,000
Total		142,220				6,867	559,000	963,000

IV. WESTERN GULF OF MEXICO.

Sabine	Texas, Louisiana	20,700	16,700	0.807	11.00	527	2,020	5,050
Trinity	Texas	17,700	9,370	.529	7.18	295	3,180	12,800
Brazos	Texas, New Mexico	48,800	9,760	.200	2.72	308	7,460	20,900
Colorado (Texas)	do	39,000	3,790	.097	1.32	120	28,100	55,700
Guadalupe	Texas	10,500	3,750	.357	4.84	118	36,000	43,400
Rio Grande[g]	Texas, New Mexico, Colorado	248,000	7,880	.032	.43	249	267,000	545,000
Pecos	Texas, New Mexico						55,000	87,800
Minor streams (western Gulf of Mexico)	Louisiana, Texas	49,000	19,500	.398	5.40	615	35,000	52,000
Total		433,700				2,232	433,760	822,650

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[a] St. Johns to Cape Henry, Va.

[b] Drainage in United States only.

[c] Included in minor streams (northern Atlantic).

[d] Cape Henry, Va., to Cape Sable, Fla.

[e] Eastern Gulf of Mexico included between Cape Sable, Fla., and Mississippi River.

[f] Included in minor streams (eastern Gulf of Mexico.)

[g] Includes drainage area and flow in Mexico, but does not include power.

Estimate of stream flow and water power in the United States—Continued.

V. MISSISSIPPI RIVER (TRIBUTARIES FROM THE EAST).

Stream.	States drained.	Drainage area (square miles).	Flow from area.				Horsepower.	
			Second-feet.	Second-feet per square mile.	Per annum.		Minimum.	Assumed maximum development.
					Depth in inches.	Billion cubic feet.		
Mississippi[a]		1,238,800	696,400	0.562	7.63	21,940	147,000	335,000
Eastern tributaries lower Mississippi, below Missouri River (exclusive of Ohio).		42,800	50,100	1.17	15.90	1,580	15,000	30,000
Ohio	Kentucky, Tennessee, Mississippi, Maryland, Pennsylvania, New York, Ohio, Illinois, Indiana, Alabama, Georgia, North Carolina, Virginia, West Virginia.	204,000	270,000	1.32	17.90	8,500	[b]40,000	[b]100,000
Tennessee	Kentucky, Tennessee, Mississippi, Alabama, Georgia, North Carolina, Virginia.						1,210,000	1,950,000
Cumberland	Kentucky, Tennessee, Virginia						76,800	159,000
Green	Kentucky, Tennessee						11,400	28,500
Kentucky	Kentucky						18,100	45,100
Licking	do						5,360	13,400
Big Sandy	Kentucky, West Virginia, Virginia						21,700	57,600
Kanawha	West Virginia, Virginia, North Carolina						402,000	1,020,000
Monongahela	West Virginia, Pennsylvania						71,000	283,000
Minor southern tributaries (Ohio)	Tennessee, Kentucky, West Virginia, Pennsylvania						31,800	7,700
Allegheny	New York, Pennsylvania							
Beaver	Pennsylvania, Ohio						6,000	18,300
Muskingum	Ohio						16,500	53,100
Scioto	do						3,630	17,200
Great Miami	Ohio, Indiana						28,700	74,600
Wabash	Indiana, Illinois						40,600	119,000
Minor northern tributaries (Ohio)	Illinois, Indiana, Ohio, Pennsylvania						10,000	41,200
Eastern tributaries, upper Mississippi, above Missouri River.	Illinois, Wisconsin, Minnesota	86,800	72,300	.833	11.30	2,280		
Illinois	Illinois						167,000	261,000
Rock	Illinois, Wisconsin						20,800	46,400
Wisconsin	Wisconsin						121,000	244,000
Chippewa	do						99,000	238,000
St. Croix	Wisconsin, Minnesota						30,000	90,000
Minor eastern tributaries upper Mississippi above Missouri River).	Illinois, Wisconsin, Minnesota						17,200	43,200
Total		333,600				12,360		

VI. MISSISSIPPI RIVER (TRIBUTARIES FROM THE WEST).

Western tributaries upper Mississippi (above Missouri River).	Minnesota, South Dakota, Iowa, Missouri	84,700	42,500	0.501	6.79	1,340	
Minnesota	Minnesota, South Dakota					17,300	46,600
Wapsipinicon	Iowa, Minnesota					4,380	10,700
Des Moines	do					50,800	222,000
Minor western tributaries upper Mississippi (above Missouri River).	Minnesota, South Dakota, Iowa, Missouri					132,000	275,000
Missouri [c]	Missouri, Louisiana, Minnesota, South Dakota, North Dakota, Montana, Wyoming, Colorado, Nebraska, Kansas.	527,000	[d]94,000	.178	2.41	2,960	300,000	600,000
Big Sioux	Iowa, Minnesota, South Dakota					21,600	38,900
Milk	Montana					30,000	50,000
Marias	do					55,600	75,400
Jefferson	do					317,000	482,000
Madison	do					216,000	276,000
Gallatin	do					94,000	126,000
Minor northern tributaries (Missouri).	Missouri, Iowa, North Dakota, South Dakota, Montana					170,000	230,000
Musselshell	Montana					23,100	26,400
Yellowstone	Montana, Wyoming					1,430,000	2,170,000
Niobrara	South Dakota, Nebraska					122,000	140,000
Platte	Nebraska, Wyoming, Colorado					290,000	657,000
Kansas	Colorado, Nebraska, Kansas					105,000	287,000
Osage	Missouri, Kansas					7,890	19,000
Minor southern tributaries (Missouri).	Missouri, Kansas, Nebraska, South Dakota, North Dakota, Montana.					190,000	300,000
Western tributaries lower Mississippi, below Missouri River (exclusive of Arkansas).	Missouri, Arkansas, Texas, Oklahoma	116,000	102,000	.880	11.90	3,220		
Arkansas	Arkansas, Missouri, Kansas, Oklahoma, Colorado, New Mexico, Texas.	177,500	65,500	.369	5.00	2,000	110,000	182,000
Cimarron	Oklahoma, Kansas, New Mexico, Texas					11,500	44,000
Canadian	Oklahoma, Texas, New Mexico					83,900	348,000
Minor tributaries Arkansas	Arkansas, Missouri, Kansas, Oklahoma, Colorado, New Mexico, Texas.					67,000	145,000
Red	Louisiana, Arkansas, Texas, Oklahoma					48,900	148,000
Minor western tributaries, lower Mississippi below Missouri River.	Minnesota, Iowa, Missouri					42,000	126,000
Total		905,200				9,580	3,948,970	7,085,000

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[a] Includes all drainage from the Mississippi to Vermilion River, inclusive.
[b] Horsepower at Louisville, Ky.
[c] Includes flow but exclusive of power in Canada.
[d] Mean annual discharge 1879-1890, inclusive, from Annual Report Chief of Engineers, 1891, p. 3826.

Estimate of stream flow and water power in the United States—Continued.

VII. ST. LAWRENCE RIVER.[a]

Stream.	States drained.	Drainage area (square miles).	Flow from area.				Horsepower.	
			Second-feet.	Second-feet per square mile.	Per annum.		Minimum.	Assumed maximum development.
					Depth in inches.	Billion cubicfeet.		
St. Lawrence at Ogdensburg, N. Y.		288,000	252,000	0.876	11.90	7,950		
Lake Superior	Minnesota, Wisconsin, Michigan	76,100	77,300	1.02	13.80		120,000	236,000
Lake Michigan	Michigan, Wisconsin, Illinois, Indiana	68,900	60,500	.878	11.90		246,000	356,000
Lake Huron	Michigan	68,900	60,000	.871	11.80		83,400	110,000
St. Clair	do	214,000	198,000	.926	12.60		3,380	6,760
Lake Erie	Ohio, Pennsylvania, New York, Michigan	[b] 40,800	22,000	[b] .540	7.33		28,000	62,300
Niagara	New York	255,000	220,000	.863	11.70		5,800,000	[c] 6,500,000
Lake Ontario[d]	do	33,000	32,100	.973	13.20		200,000	400,000
Lake Champlain (Richelieu River)	New York, Vermont	7,750	13,500	1.74	23.60	426	102,000	147,000
Minor St. Lawrence tributaries in New York below Ogdensburg.	New York	3,970	6,550	1.65	22.40	207	99,700	272,000
Total		299,720				8,583	6,682,480	[e] 8,090,060
VIII. COLORADO RIVER.								
Colorado River above Yuma, Ariz.	Utah, Nevada, California, Arizona, New Mexico, Colorado, Wyoming.	225,000	16,500	0.0733	1.00	521	1,150,000	2,080,000
Gila	Arizona, New Mexico						72,500	241,000
Little Colorado	do						12,000	24,000
San Juan	Arizona, New Mexico, Utah, Colorado						149,000	341,000
Grand	Colorado, Utah						703,000	1,310,000
Green	Utah, Wyoming, Colorado						812,000	1,510,000
Minor tributaries	Arizona, New Mexico, Utah, Nevada, California						20,000	40,000
Total		225,000				521	2,918,500	5,546,000
IX. SOUTHERN PACIFIC.[f]								
Minor streams (southern Pacific)	California	22,800	7,410	0.325	4.42	233	36,400	88,300
San Francisco Bay:								
Sacramento	California, Oregon	31,400	45,500	1.45	19.70	1,420	2,420,000	4,580,000
San Joaquin	California	[g] 16,500	[g] 16,800	[g] 1.02	[g] 13.80	[g] 530	[h] 759,000	[h] 3,140,000
Total		70,700				2,193	3,215,400	7,808,300

X. NORTHERN PACIFIC.[i]

Columbia[j]	Oregon, Idaho, Wyoming, Montana, Washington, Nevada.	231,400	312,000	1.35	18.30	9,850	4,060,000	6,250,000
Willamette	Oregon						602,000	1,670,000
Des Chutes	do						953,000	1,920,000
John Day	do						79,700	158,000
Snake	Oregon, Washington, Idaho, Wyoming, Nevada						1,880,000	4,300,000
Spokane	Washington, Idaho						237,000	610,000
Pend Oreille (Clark Fork)	Idaho, Montana						1,530,000	2,620,000
Yakima	Washington						194,000	626,000
Kootenai	Montana, Idaho						207,000	357,000
Minor tributaries, Columbia	Oregon, Washington						718,000	1,230,000
Puget Sound	Washington	14,300	59,200	4.15	56.30	1,870	719,000	1,400,000
Minor streams, Northern Pacific	California, Oregon, Washington	44,700	111,000	2.48	33.60	3,500	1,800,000	3,560,000
Total		290,400				15,220	12,979,700	24,701,000

XI. GREAT BASIN.

Wasatch Mountains drainage	Utah, Wyoming, Idaho	44,300	7,620	0.172	2.33		92,000	149,000
Humboldt	Nevada	25,200	2,420	.096	1.30		20,000	30,000
Sierra Nevada drainage	California, Nevada, Oregon	[h]55,900	[h]18,900	[h].338	[h]4.58		[k]396,000	[k]607,000
Minor streams in Great Basin	California, Nevada, Utah, Oregon	97,600	10,100	1.03	1.40		10,000	15,000
Total		223,000					518,000	801,000

XII. HUDSON BAY.

Red (of the North)[l]	North Dakota, Minnesota	50,000	6,420	0.128	1.74	203	25,000	52,000
St. Mary	Montana	650	1,510	2.31	31.40	48	30,500	120,000
Rainy[m]	Minnesota	11,500	11,500	1.00	13.60	363	20,300	40,600
Total		62,150				614	75,800	212,600

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[a] Values of drainage areas and discharge of the Great Lakes drainages derived chiefly from report of E. S. Wheeler, assistant engineer, U. S. Army. The discharge value is given for each of the Great Lakes as a unit from 1860 to 1892, and includes the run-off from both land and water surfaces. It shows the total discharge from both United States and Canadian territory.

[b] Includes Lake St. Clair.

[c] 3,500,000 horsepower at Niagara Falls on the basis of mean annual discharge.

[d] Includes Oswegatchie River and minor St. Lawrence tributaries above Ogdensburg, N. Y.

[e] Total horsepower of Niagara River and of tributaries to the Great Lakes in the United States.

[f] Southern Pacific included between Mexican line and Point Bonita, Cal.

[g] Exclusive of Tulare Lake drainage (see Sierra Nevada drainage).

[h] Includes Tulare Lake drainage.

[i] Northern Pacific included between Point Bonita, Cal., and Canadian line.

[j] Includes drainage area and flow in Canada, but does not include power.

[k] Does not include Tulare Lake drainage (see San Joaquin River).

[l] Includes drainage area and flow of Pembina and Mouse rivers in Canada, but does not include power.

[m] Drainage in United States only.

Estimate of stream flow and water power in the United States—Continued.

GENERAL SUMMARY.

Principal drainages.	Drainage area (square miles).	Flow per annum (billion cubic feet).	Minimum.	Assumed maximum development.
Northern Atlantic to Cape Henry, Va.	159,879	8,942		
Southern Atlantic to Cape Sable, Fla.	123,920	5,560	1,253,000	1,957,800
Eastern Gulf of Mexico to Mississippi River	142,220	6,867	550,000	963,000
Western Gulf of Mexico west of Vermilion River	[a] 433,700	[a] 2,232	433,760	822,650
Mississippi River (tributaries from east)	333,600	12,360		
Mississippi River (tributaries from west, including Vermilion River)	905,200	9,580	3,948,970	7,085,000
St. Lawrence River to Canadian line	[b] 299,720	[b] 8,583	6,682,480	8,090,060
Colorado River above Yuma, Ariz.	225,000	521	2,918,500	5,546,000
Southern Pacific to Point Bonita, Cal.	70,700	2,193	3,215,400	7,808,300
Northern Pacific	290,400	15,220	12,979,700	24,701,000
Great Basin	223,000		518,000	801,000
Hudson Bay	62,150	614	75,800	212,600
Total	3,269,489	72,672		

[a] Includes Rio Grande in Mexico.

[b] Includes drainage in Canada.

CONCENTRATION OF OWNERSHIP OF WATER POWERS.

By HERBERT KNOX SMITH,
Commissioner of Corporations.

The water-power situation has been greatly changed by recent improvements in electric-power transmission. Two-hundred-mile transmission is now regarded as commercially possible even in the cheaper coal areas. A two-hundred-mile radius opens an area of 120,000 square miles for the marketing of power from a given power plant.

A strong movement toward concentrating the control of water powers has accompanied this change. A very significant fact is that this concentration has taken place practically in the last five years. The chief existing concentrations are as follows:

(1) *General Electric*—being those power companies controlled by or having direct personal connections with the General Electric Company or its subsidiary corporations.

(2) *Westinghouse*—being those similarly connected with the Westinghouse Electric and Manufacturing Company, the Westinghouse Machine Company, and other Westinghouse interests.

(3) *Other concentrations* of water power which can not at present be identified with either of the first two.

Inter-company relations are easily concealed. Strictly judicial proof of such community of interests is rarely obtainable, nor is it necessary for practical purposes. It is sufficient to give, as herein, the significant evidential facts, leaving the obvious deductions to be made therefrom.

Therefore the General Electric and the Westinghouse concentrations are classified in the following groups:

(*a*) Those where a control by one or the other of these parent companies, directly or through subsidiary corporations, is admitted.

(*b*) Those where such control is inferred from substantial evidence (hereinafter summarized) with reasonable conclusiveness.

(*c*) Those where such control is at least partially indicated, though not proven, by the available evidence.

This report does not by any means assume to be a complete survey even of the present conditions of concentration. There may be many further affiliations as yet undiscovered. It is compiled, with two exceptions, from such data as the Bureau of Corporations had collected up to January 14, 1909, in the course of an investigation not yet completed.

The exact relations, if any, between these two groups (General Electric and Westinghouse) can not now be stated. General Electric and Westinghouse patents have been pooled since 1896, and certain individuals are interested in both General Electric and Westinghouse power companies.

(1) GENERAL ELECTRIC.

The control of the General Electric Company is shown directly or through subsidiary corporations, or indicated by the appearance of the names of certain individuals unquestionably connected with the General Electric Company.

Such subsidiary corporations are:

United Electric Securities Company (Maine, 1890).

Electrical Securities Corporation (New York, 1904).

Electric Bond and Share Company (New York, 1905).

Such individuals most closely connected with General Electric Company water-power control are—

Sydney Z. Mitchell, vice-president and treasurer Electric Bond and Share Company (General Electric; see above), formerly with Stone & Webster, of Boston, to be mentioned later.

J. D. Mortimer, assistant secretary Electric Bond and Share Company (General Electric; see above) and director of American Gas and Electric Company.

C. N. Mason, vice-president Electrical Securities Corporation and of United Electric Securities Company (General Electric; see above).

H. L. Doherty, president American Gas and Electric Company, which in 1908 controlled at least 19 lighting and gas companies in various parts of the United States, and is, in turn, controlled by the Electric Bond and Share Company (General Electric; see above).

Other names which may be mentioned are—

C. A. Coffin, president General Electric Company.

A. W. Burchard, assistant to the president, General Electric Company, and director of American Gas and Electric Company (General Electric).

C. W. Wetmore, director of Electric Bond and Share Company.

Hinsdill Parsons, vice-president General Electric Company and director of Electric Bond and Share Company.

(*a*) Those water-power companies which are admittedly controlled by the General Electric Company or its subsidiary companies are—

Schenectady Power Company, New York, developments on the Hoosick River at Schaghticoke and Johnsonville, with a total development of 26,000 horsepower. This company is owned outright by the General Electric Company.

Carolina Power and Light Company, at Raleigh, N. C., with 4,000 horsepower installed on the Cape Fear River, and leasing power, in addition, on the Neuse River. The stock of this company is held by the Electric Bond and Share Company (General Electric) and voted by Mr. J. D. Mortimer. C. Elmer Smith, of Smith interests in Westinghouse group, is also interested.

Rockingham Power Company, in North Carolina, on the Yadkin River, in process of construction, with an installation to be of 32,000 horsepower. This company is financed by the Electrical Securities Corporation (General Electric), C. N. Mason of the latter being president. C. Elmer Smith (see above) is also interested.

Animas Power and Water Company, Colorado, on the Animas River, with 8,000 horsepower installed, is controlled through the Electric Bond and Share Company (General Electric).

Central Colorado Power Company, in Colorado, together with the Eastern Colorado Power Company, which it owns, has on the Grand

River and Middle Boulder Creek installations to be of 63,000 horsepower and power sites in addition amounting to at least 25,000 horsepower. This company is being financed by W. P. Bonbright & Co., of New York City; Lee, Higginson & Co., of Boston, and the Electric Bond and Share Company (General Electric). Mr. H. L. Higginson, of Lee, Higginson & Co., is a director of the General Electric Company. Mr. S. Z. Mitchell, of the Electric Bond and Share Company, is a vice-president and member of the executive committee of this power company.

(*b*) Those water-power companies, the control of which by the General Electric Company or its subsidiary companies is reasonably inferred, are—

Montgomery Light and Water Power Company, near Montgomery, Ala., on the Tallapoosa River, with an installation of 6,000 horsepower. H. L. Doherty, president, American Gas and Electric Company (General Electric), is first vice-president of this company.

The Summit County Power Company, at Dillon, Colo., with an installation of 1,600 horsepower, has Mr. H. L. Doherty, of American Gas and Electric Company (General Electric), on its directorate.

Butte Electric and Power Company (Montana), a holding company for various subsidiary power companies, to wit: Montana Power Transmission Company, Madison River Power Company, Billings and Eastern Montana Power Company. These companies comprise six water-power developments in operation, with a total installation of 43,000 horsepower. The holding company (Butte Electric) is apparently controlled jointly by C. W. Wetmore, of Electric Bond and Share Company (General Electric), and C. A. Coffin, president of General Electric Company. P. E. Bisland, secretary, was formerly with Electrical Securities Corporation (General Electric).

Washington Water Power Company has three developments in Washington and Idaho, on the Spokane River, with a total installation of 61,000 horsepower. Mr. Hinsdill Parsons, vice-president of General Electric Company and Electric Bond and Share Company (General Electric), is on the directorate.

Great Western Power Company, in California, on the north fork of the Feather River in Butte County, with an installed capacity of 53,000 horsepower. On its directorate are Mr. A. W. Burchard, of the General Electric Company, and Mr. A. C. Bedford, of the Standard Oil Company. Mr. Bedford is also president of the Portland General Electric Company (see below).

(*c*) Control partially indicated.

There are also a number of other water-power companies, with a total of about 420,000 horsepower (including installations and power sites), whose connection with the General Electric Company is at least partially indicated, though the evidence thereto is by no means conclusive.

(2) WESTINGHOUSE.

The Westinghouse group contains the following companies:

The Security Investment Company;

Electric Properties Company (New York, 1906), Westinghouse, Church, Kerr & Co., subsidiary of Electric Properties Company.

Smith interests, represented by C. Elmer Smith and S. Fahs Smith, of S. Morgan Smith Company, important manufacturers of water turbines. While C. Elmer Smith is interested in at least two General Electric power companies (Carolina and Rockingham; see above), the Smith interests seem especially harmonious with the Westinghouse group, and are so classified.

The individual names most prominently identified are:

John F. Wallace, of New York, president Electric Properties Company.

George C. Smith, of Pittsburg and New York, vice-president of the Security Investment Company and vice-president and director of the Electric Properties Company.

C. Elmer Smith, of Smith interests.

(*a*) Those power companies which are admittedly Westinghouse are:

Atlanta Water and Electric Power Company, on the Chattahoochee River above Atlanta, Ga., with an installation of 17,000 horsepower. C. Elmer Smith is president, and George C. Smith and S. Fahs Smith directors.

Ontario Power Company of Niagara Falls, a Canadian corporation on the Canadian side, with an installation of 66,000 horsepower. Together with its distributing company in the United States, the Niagara, Lockport, and Ontario Power Company, it is known as a Westinghouse concern, H. H. Westinghouse being president of the latter, and stock being held therein by the Security Investment Company (Westinghouse).

(*b*) Those power companies whose connection with Westinghouse interests is inferred from substantial evidence are:

Albany Power and Manufacturing Company, near Albany, Ga., with 3,500 horsepower installed, on the Kinchatoonee, and owning beside a site on the Flint River, estimated at 10,000 horsepower, has for its vice-president C. Elmer Smith (Smith interests).

Electric Manufacturing and Power Company, on the Broad River, near Spartanburg, S. C., with 11,000 horsepower installed, has on its directorate E. H. Jennings, of Pittsburg, a director of the Electric Properties Company (Westinghouse).

Savannah River Power Company, on the Savannah River, near Anderson, S. C., has an installed development of 3,000 horsepower, and owns besides a site of 6,000 horsepower. This company has on its directorate C. Elmer Smith (Smith interests).

Gainesville Electric Railway Company, with 1,500 horsepower installed, on the Chestagee River, a tributary of the Chattahoochee, near Gainesville, Ga. Eighty-five per cent of its stock is owned by the North Georgia Electric Company (Smith interests).

North Georgia Electric Company; one development of 3,000 horsepower and at least seven other power sites on the upper waters of the Chattahoochee, and through the Etowah Power Company, personally identified with itself, it owns four other sites on the headwaters of the Coosa River. C. Elmer Smith is vice-president.

Chattanooga and Tennessee River Power Company, in process of construction at Hale Bar, on the Tennessee River, below Chattanooga, in cooperation with the War Department, by which the Government obtains slack-water navigation. The company in return receives ownership of the power of 58,000 horsepower to be installed. This company is being personally financed by A. N. Brady, of New York, a director of the Westinghouse Electric and Manufacturing Company. Mr. Brady is also a director of the American Tobacco Company, whose interests control the Southern Power Company (see below).

Northern Colorado Power Company, with a steam development at Lafayette, Colo., and reported as having acquired a water power site of 20,000 horsepower on South Platte River, has John F. Wallace and George C. Smith of the Electric Properties Company (Westinghouse) on its directorate.

(*c*) Control partially indicated.

There are also a number of other water-power companies, with a total of about 102,000 horsepower (including installations and sizes), whose connection with the Westinghouse Company is at least partially indicated, though the evidence thereto is by no means conclusive.

(3) OTHER CONCENTRATIONS.

The General Electric and Westinghouse companies present the most important examples of water-power concentration, as above set forth. There are, however, a number of other companies and interests further showing the facts and tendencies of concentration.

The more important instances are as follows:

The Gould interests located in Virginia, with undeveloped powers and power sites on the James and Appomattox amounting to 20,000 horsepower, and owning besides other sites on the Appomattox and Rappahannock rivers.

Southern Power Company, the largest operating power company in the South, has 90,000 horsepower installed in three developments, 31,000 horsepower in process of construction, and at least seven other power sites in North Carolina and South Carolina, with a total potential capacity of 75,000 horsepower. This company supplies 110 cotton mills and other factories in at least 28 towns, including a population of about 200,000. Messrs. B. N. Duke, J. B. Duke, and Junius Parker, of the American Tobacco Company, are officers and directors.

Stone & Webster, of Boston. This concern controls or manages powers and power sites in Florida, Georgia, Minnesota, and Wisconsin, and in the Puget Sound region, with a total capacity of about 150,000 horsepower. Mr. Sydney Z. Mitchell, now of the Electric Bond and Share Company (General Electric), was formerly connected with Stone & Webster, and in 1908, according to Moody's Manual, 1908, was still a director in three of Stone & Webster's managed corporations, to wit, Puget Sound Electric Railway, Tacoma Railway and Power Company, and Puget Sound Power Company.

Charles H. Baker interests; having proposed developments in Alabama estimated at 130,000 horsepower.

Commonwealth Power Company, together with the Grand Rapids-Muskegon Power Company (both under same interests), controlling 13 developed water powers in Michigan, with a total installation of 43,000 horsepower. A harmonious connection apparently exists with the Eastern Michigan Power Company, which controls all the power sites on the Au Sable River, Michigan.

United Missouri River Power Company, a holding company controlling at least three subsidiaries, which, with a closely related company, have five developed powers and one in construction, making a total of 57,500 horsepower.

Portland General Electric Company, with developments on the Clackamas and Willamette rivers amounting to 22,500 horsepower, near Portland, Oreg. A. C. Bedford, a director of the Standard Oil Company, is president, and F. D. Pratt, also of Standard Oil Company, is a director.

Pacific Gas and Electric Company. This is a very important holding company of the California Gas and Electric Corporation and the San Francisco Gas and Electric Company. These two latter companies in turn represent the consolidation or acquisition of the stock or property of over thirty power or power-distributing companies in California. They control 11 water-power developments, with a total installed plant of 118,000 horsepower.

Pacific Light and Power Company, with another company controlled by the same interests, known as the Huntington interests, represent eight developments in California, with a total of 30,000 horsepower. Henry E. Huntington is vice-president and Howard E. Huntington a director.

Edison Electric Company, with six developments in California and a total of 33,000 horsepower. This company is reported to have control of about 75 per cent of the available undeveloped water powers in southern California.

Hudson River Electric Power Company, a holding company for the Hudson River Water Power Company, Hudson River Power Transmission Company, Empire State Power Company, with developments at Spiers Falls and Mechanicsville on the upper Hudson, and Schoharie Creek near Amsterdam, N. Y., amounting to 45,000 horsepower installed, and sites owned in the Mohawk, Sacandaga, and upper Hudson valleys, amounting to 30,000 horsepower, or a total of 75,000 horsepower. C. Elmer Smith was director of the holding company to within a year.

Telluride Power Company, together with the Beaver River Power Company, controlled by the same interests, has 11 developments in Colorado, Utah, and Idaho, with a total present installation of 52,000 horsepower.

SUMMARY.

An estimate of the water power, developed and potential, now controlled by the General Electric interests, admitted or sufficiently proven, is about 252,000 horsepower; by the Westinghouse interests, similarly known, about 180,000 horsepower, and by other large power companies, 875,000 horsepower. This makes a total of 1,307,000 horsepower. Adding the horsepowers of the third class (*c*), those whose connection with these two great interests is at least probable, to wit, 520,000 horsepower, we have a small group of 13 selected companies or interests controlling a total of 1,879,000 horsepower developed and undeveloped.

Assuming that the water power at present in use by water-power plants in the United States is 5,356,000 horsepower, as estimated by the United States census and the Geological Survey from figures of installation, we see that approximately a quantity of horsepower equal to more than 35 per cent of that amount is now probably controlled by this small group of interests. Furthermore, this percentage by no means tells the whole truth. The foregoing powers naturally represent a large proportion of the best power sites. These sites are strategic points for large power and market control. Poorer sites will not geenerally be developed until these strategic sites are developed to their full capacity. And should these strategic sites be "coupled up" they become still more strategic. There are powerful economic reasons for such coupling. The great problem of water-power companies is not only that of the "uneven load," common to all power companies, but especially that of an uneven source of power, because of the fluctuating flow of the stream. A coupling up utilizes not only the different storages in the same drainage basin, but, of still greater import, the different drainage flows of different basins. Also, by coupling up, powers which have largely "day loads" can at night help out other powers which have largely "night loads," and vice versa. Coupling up is rapidly in progress in the United States. The Niagara Falls Power Company and the Canadian Niagara Power Company are coupled. The Southern Power Company, in North Carolina and South Carolina; the Commonwealth Power Company, in Michigan; the Pacific Gas and Electric Company, the Pacific Light and Power Company, and the Edison Electric Company, in California—each concern has its various developments coupled up into one unit.

The economic reasons urging water-power concentration are thus obvious. The facts set forth above show the very rapid and very recent concentration that has already occurred, practically all in the last five years. These economic reasons and business facts indicate clearly the further progress toward concentration that is likely to occur in the near future. It is obvious that the effect on the public of such present and future conditions is a matter for serious public consideration.

CONTROL OF CATCHMENT AREAS.

By Horatio N. Parker,

Water Resources Branch, United States Geological Survey.

Catchment areas, annual consumption, and total money investment of the water works of 42 cities which derive their water supplies from impounded surface waters and which have populations of over 30,000.

City.	Catchment area.	Reservoir capacity.	Annual consumption.	Total investment.		
				Cost of construction.	Bonded indebtedness.	Maintenance.
	Sq. miles.	*Gallons.*	*Gallons.*			
Altoona, Pa.	9.00	[a] 425,000,000	547,500,000	$910,148	$479,000	$45,000
Baltimore, Md	347.00	2,310,000,000	22,995,000,000	12,000,000	850,000	400,000
Boston, Mass.	[b] 212.38	82,966,530,000	40,250,000,000	40,459,778	40,500,000	318,052
Bridgeport, Conn	40.80	10,000,000	7,300,000,000	....	....	....
Brockton, Mass	7.70	5,700,000,000	714,340,000	1,713,300	1,485,000	38,000
Butte, Mont	....	290,000,000	2,190,000,600	....	....	....
Cambridge, Mass	6.80	2,270,000,000	3,386,180,000	6,467,153	3,787,600	75,702
Charleston, S. C	49.00	3,127,820,000	1,204,500,000	2,456,682	1,250,000	52,245
Denver, Colo	3,910.00	110,000,000,000	15,881,000,000	....	....	....
Elmira, N. Y	....	117,500,000	1,546,900,000	895,000	....	115,000
Fall River, Mass	27.54	....	1,640,000,000	2,076,450	1,550,000	124,972
Fitchburg, Mass	7.40	2,000,000	1,095,000,000	1,400,000	446,000	37,300
Hartford, Conn	13.00	2,035,000,000	2,190,000,000	3,567,191	675,000	150,000
Haverhill, Mass	20.10	128,000,000	1,839,000,000	1,463,047	610,833	25,137
Holyoke, Mass	18.05	1,600,000,000	2,127,840,000	1,295,308	350,000	61,712
Jersey City, N. J	....	129,200,000	12,045,000,000	5,200,000	600,000	445,000
Johnstown, Pa	5.50	283,000,000	....	1,500,000	....	....
Los Angeles, Cal	502.50	898,000,000	11,680,000,000	[j] 3,983,693	[k] 3,480,250	201,107
Lynn, Mass	....	....	1,873,450,000	2,900,891	1,778,500	117,389
Newark, N. J	....	9,000,000,000	93,482,500,000	8,959,790	7,993,500	250,000
New Bedford, Mass	[c] 12.80	[d] 5,550,000,000	2,524,661,000	3,332,800	1,638,000	109,443
New Haven, Conn	56.40	2,837,000,000	8,395,000,000	....	....	....
New York, N. Y. (boroughs of Manhattan and Bronx)	[e] 382.00	[f] 108,638,000,000	[f] 119,720,000,000	[g] 86,350,562	....	1,000,000
Norfolk, Va	....	....	2,482,000,000	1,250,000	....	....
Oakland, Cal	....	6,300,000,000	....	4,520,000	....	100,000
Pawtucket, R. I	27.80	1,475,000,000	2,633,000,000	1,946,848	1,285,000	53,153
Portland, Me	....	30,6[illegible],000	2,190,000,000	2,677,970	....	....
Portland, Oreg	....	6,000,000	6,935,000,000	5,204,650	2,900,000	78,516
Reading, Pa	218.60	186,022,000	3,768,260,000	33,213,725	400,000	50,316
Rochester, N. Y	[h] 66.20	229,500,000	5,621,000,000	9,028,000	5,610,000	115,000
St. Paul, Minn	....	18,000,000	3,732,000,000	4,517,329	2,367,000	60,337
Salem, Mass	....	20,000,000	1,090,426,000	1,947,200	143,000	31,306
Salt Lake City, Utah	....	9,012,000	5,110,000,000	4,810,000	1,575,000	55,000
San Francisco, Cal. (prior to fire)	....	29,000,000,000	12,344,665,000	....	....	554,000
Scranton, Pa	....	2,000,000,000	9,125,000,000	....	....	....
Springfield, Mass	[i] 18.00	1,500,000,000	4,000,000,000	2,509,525	555,000	54,700
Syracuse, N. Y	70.25	121,000,000	4,380,000,000	5,000,000	4,075,000	100,000
Taunton, Mass	52.00	10,300,000,000	818,774,000	1,367,801	853,500	33,988
Waterbury, Conn	19.50	920,000,000	2,728,831,000	1,819,640	865,000	24,000
Wilkesbarre, Pa	....	4,000,000	....	....	....	....
Worcester, Mass	....	2,550,000,000	2,954,617,000	4,406,202	3,830,000	60,000

[a] Exclusive of a reservoir of 300,000,000 gallons capacity.

[b] Metropolitan Water Works.

[c] Exclusive of a storage reservoir in Acushnet, which has a catchment area of 5.25 square miles.

[d] An additional storage reservoir of 1,600,000,000 gallons capacity is under construction.

[e] On Croton, Bronx, and Byram rivers.

[f] On Croton River, including the new Croton reservoir to be finished in 1911, and on Bronx and Byram rivers.

[g] 1832 to 1898, inclusive.

[h] Exclusive of Hemlock Lake.

[i] Little River supply, now 40 per cent completed, is to replace present supply; will have a catchment area of 48 square miles and storage capacity of 2,600,000,000 gallons.

[j] Amount spent since the works were taken over by the city in February, 1902.

[k] Original, 4,017,500.

ORIGINAL FORESTS.

By R. S. Kellogg,
United States Forest Service.

The original forests of the United States exceeded in the quantity and variety of their timber the forests of any other region of similar size on the globe. Five great forest types were distinguished—the northern, southern, central, Rocky Mountain, and Pacific coast. Their boundaries are roughly sketched in the accompanying diagram.

The northern forests extended from Maine through New England, across New York and considerable of Pennsylvania, through the main portions of Michigan and Wisconsin to Minnesota, with an extension along the high Appalachian ridges as far southwestward as northeastern Alabama and northern Georgia. Roughly, it covered some 150,000,000 acres. In this forest the cone-bearing trees predominated. It was the home of the white pine. Associated with it were red pine, spruce, hemlock, cedar, balsam fir, the birches, black cherry, sugar maple, and several other hardwoods of minor importance. The total stand of timber of all kinds in the northern forest originally was not less than 1,000,000,000,000 board feet.

The northern extremity of the southern forest was in southern New Jersey, widening out southward and westward to cover much of Virginia, nearly all of North Carolina and South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, with a portion of eastern Texas and southern Arkansas, and a small extension into southern Missouri. This, too, was a coniferous forest. The yellow pines predominated heavily. Interspersed with the pines in localities suitable for their growth were cypress, oaks, gums, magnolia, yellow poplar, and a variety of other hardwoods. The total original area of this forest was perhaps 220,000,000 acres, and it contained at least 1,000,000,000,000 feet of merchantable timber.

In rough outline, the central forest stretched from the Atlantic coast to the prairies, with limitations on the other two sides by the northern and southern forests. There were no sharp demarcations between it and the other types, and it was extremely irregular in shape. It was the only forest region of the United States in which the hardwoods predominated, and they occurred in extreme abundance. Walnut, oak, elm, hickory, cottonwood, maple, basswood, chestnut, sycamore, red gum, ash, and many other trees here reached their maximum development. It can be conservatively estimated that the original area of the central hardwood forest was not less than 280,000,000 acres, and that the amount of merchantable timber standing upon it before clearing began was at least 1,400,000,000,000 board feet.

The Rocky Mountain forest, as its name indicates, was typical of the Rocky Mountain region from Idaho and Montana through Wyoming, Utah, and Colorado to Arizona and New Mexico. It was separated by the prairie and the plains region from the eastern forests and by desert areas from the Pacific forest. This forest grew chiefly on the higher plateaus and mountain slopes and was almost entirely coniferous. Western yellow pine occurred throughout, while lodgepole pine, larch, spruce, Douglas fir, giant arborvitæ, and other softwoods were abundant in many localities. The broken character of this forest makes the timber and area extremely difficult to estimate. It is probable, however, that the original extent was not less than 110,000,000 acres, and that it contained 400,000,000,000 board feet of merchantable saw timber.

The Pacific type of forest characterized California, Oregon, and Washington, reaching its maximum development along the Sierras and west of the Cascade Range. So far as saw timber was concerned it was almost exclusively a coniferous forest, and consisted chiefly of Douglas fir, western yellow pine, redwood, giant aborvitæ, sugar pine, and various other firs and spruces. The original area of this forest was at least 90,000,000 acres, and the amount of merchantable timber which it contained was not less than 1,400,000,000,000 board feet.

Without exaggeration, then, we may say that the original forests of the United States covered 850,000,000 acres and contained 4,800,000,000,000 board feet of merchantable saw timber according to present standards of utilization. In addition there were probably 150,000,000 acres of scrubby forest and brush land, chiefly in the West, which has been and still is a source of much post and fuel material.

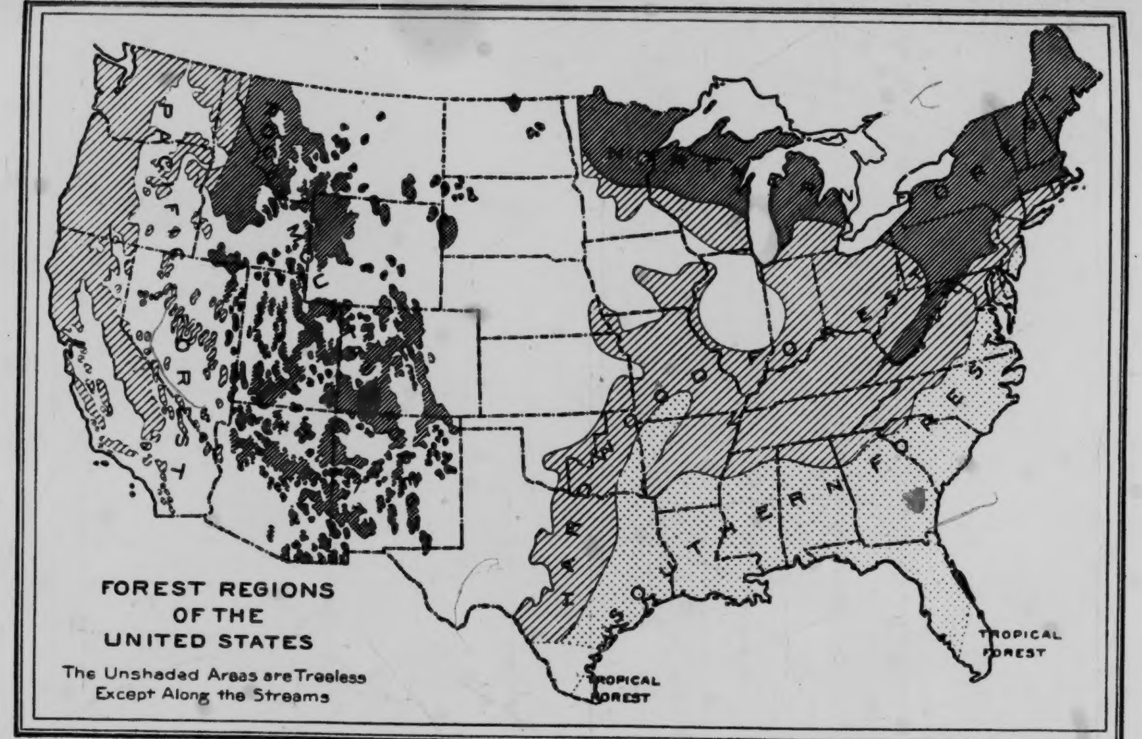
FOREST REGIONS
OF THE
UNITED STATES
The Unshaded Areas are Treeless
Except Along the Streams
PACIFIC FOREST
ROCKY MOUNTAIN FOREST
NORTHERN FOREST
HARDWOOD FOREST
SOUTHERN FOREST
TROPICAL FOREST
TROPICAL FOREST

FIG. 1.

STANDING TIMBER IN WOOD LOTS.

By **Wesley Bradfield.**
United States Forest Service.

The amount of woodland owned by farmers in the United States, together with the amount of stumpage which they control, bears a very important relation to the total amount of timberland and the total resources of the country. Although the estimates given in this report are subject to revision, they are as nearly correct as may be obtained at the present time.

It is estimated that the farmers own 38 per cent of the total area of forest land and 12.4 per cent of the total amount of merchantable timber. On the average, not more than 30 per cent of these resources reaches the general timber markets of the country; this amount affects only local sections, as the greater percentage of the timber cut from farmers' wood lots is consumed in the vicinity of cutting. This percentage is practically all that can be relied upon at the present time from this source of ownership to aid in meeting the general market demands. For, while a certain percentage of young timber is gradually reaching a merchantable size, the acreage in farmers' holdings is gradually decreasing, mainly through the clearing of woodland for agriculture, and the amount of timber available for the future is more rapidly decreasing, because the farmer's wood lot is by no means reserved entirely for the production of a future supply for the owner or for the local markets. A far more important place, however, is held by the wood lot in that it provides a great amount of timber of all sorts needed on the farm for rough building, general repairs, fences, and fuel. This timber is not always used to the best advantage, and it is very evident that if this source of supply were more carefully managed, the influence which the farmers' holdings have on the general market would be much greater than at the present time.

It is estimated that in the whole United States the farmers own over 204,000,000 acres of woodland, 46 per cent of which contains merchantable timber, 43 per cent cord-wood timber, and 11 per cent is in brush land. The estimated stand on these holdings is 311,000,000,000 feet of timber and 1,500,000,000 cords of wood.[a] Its distribution throughout the eastern and western halves of the United States is shown by the following table:

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[a] In addition to approximately 1,000,000 cords of wood on the second type of woodland, there are also half a million cords of wood on the merchantable timbered area not included in the tabular estimates.

Percentage of total area of section owned by farmers.

	In the East.	In the West.
Per cent of total woodland	52	7
Per cent of total acreage	94	6
Per cent of wood-lot area containing merchantable timber	43	83
Per cent of wood-lot area containing cord wood	45	14
Per cent of wood-lot area in brush land	12	3
Per cent of stand of timber in wood lots	74	26
Per cent of cord wood in wood lots	99	1

This table shows that in the eastern half of the United States the percentage of the total amount of woodland owned by the farmers is about one-half of the total timber acreage in that section of the country. The relative importance of the farmers' holdings in the western half is very small, as they own only 7 per cent of the total timber acreage, and practically none of their timber has any effect on general market conditions. Provided that the quality of the timber remains the same, the money value of the farmers' wood-lot holdings represents even the smaller proportion in its relation to the total value of the timber stumpage, as these holdings are isolated and can be exploited only at a cost which is greater in proportion to the expense of marketing the timber held by all other sources.

The relation of the farmers' wood lot to the total forested area throughout the United States is given in more detail in the following groups of States:

In the New England States, together with New York and New Jersey, 47 per cent of the forested area is held by farmers. Of this amount 29 per cent is merchantable timber land, 54 per cent is cord-wood-timber land, and 17 per cent is brush land. The stumpage owned by farmers is approximately 15,798,000,000 feet and over 96,000,000 cords of wood. The general quality of the merchantable timber is of medium grade. The predominating species are the oaks and chestnut; spruce and white pine; maple, birch, and hickory. The cord-wood land in this and in all of the following sections represents a potential future timber production of very great importance, as the forests on this cord-wood land, so called, is rapidly growing into the merchantable timber class.

In the States of Delaware, Maryland, and Virginia, 81 per cent of the woodland is owned by farmers, of which 42 per cent contains merchantable timber, 50 per cent is cord-wood timber land, and 8 per cent is brush land. The stand of timber in these States is approximately 15,634,000,000 feet and 49,000,000 cords of wood. The quality of the merchantable timber is poor. The predominating species are the oaks, chestnut, maple, beech, hickory, and basswood, with scattered stands of loblolly pine, pitch pine, and scrub pine.

In the South Atlantic and Gulf States 50 per cent of the woodland is owned by farmers, of which 48 per cent contains merchantable timber, 40 per cent is cord-wood land, and 12 per cent brush land. The stand of timber in wood lots is approximately 110,426,000,000 feet and 332,000,000 cords of wood. The quality of the merchantable timber is good. The predominating species are longleaf, shortleaf, and loblolly pine, and cypress along the coastal plain; oaks, beech, maple, and other hard woods throughout the mountain section.

In the States of Pennsylvania, West Virginia, Kentucky, and Tennessee 62 per cent of the woodland is owned by farmers, of which 38 per cent contains merchantable timber, 50 per cent is cord-wood land, and 12 per cent is brush land. The stand of timber is approximately 33,332,000,000 feet and 111,000,000 cords of wood. The quality of the merchantable timber is poor. The predominating species are the black oaks, beech, maple, white oak, chestnut oak, chestnut, and hickory in the mountain regions, and black oak, beech, white oak, hickory, gums, and maple in the better agricultural regions.

In the Lake region the farmers own 40 per cent of the timber-land area, of which 40 per cent contains merchantable timber, 41 per cent is cord-wood land, and 19 per cent is brush land. The stand of merchantable timber is approximately 24,003,000,000 feet and 119,000,000 cords of wood. The quality of the merchantable timber is good. The predominating species are the oaks, elm, basswood, hickory, maple, beech, birch, white pine, Norway pine, and jack pine.

In Arkansas and Missouri 49 per cent of the timber-land area is owned by farmers; of this acreage 51 per cent contains merchantable timber, 43 per cent is cord-wood land, and 6 per cent is brush land. The stand of timber is approximately 20,748,000,000 feet and 70,000,000 cords of wood. The quality of merchantable timber is poor. The predominating species are black, post, pine, white, and chinquapin oaks, sycamore, gums, and elms.

In the prairie States, which contain only a small percentage of timber land in comparison with their total area, the farmers own 70 per cent of the woodland. Of this amount 37 per cent contains merchantable timber, 48 per cent is cord-wood land, and 15 per cent is brush land. The stand of timber is approximately 11,799,000,000 feet and 51,000,000 cords of wood. The quality of the merchantable timber is poor. The predominating species are the oaks, maple, elm, sycamore, cottonwood, and birch. All of the above States are included in the eastern half of the United States.

In the West the farmers own only 7 per cent of the total acreage of forest land, of which 83 per cent is merchantable timber land, 14 per cent cord-wood land, and 3 per cent brush land. The stand of timber on farmers' holdings is approximately 79,480,000,000 feet and 9,000,000 cords of wood. To show more definitely the relation between the farmers' holdings in the East and the West, the eastern half of the United States contains 94 per cent of the total acreage owned by farmers, 89 per cent of the wood-lot area which contains merchantable timber, 98 per cent of the wood-lot area containing cord wood only, 99 per cent of the brush-land area, 74 per cent of the total amount of stumpage owned by farmers, and 99 per cent of the total amount of cord wood on farmers' holdings.

Although the amount of standing timber in wood lots is comparatively small, it is very evident that the supply of timber which may be derived from farmers' wood lots can be greatly increased over the present percentage of merchantable timber which the farmers place on the market. Over one-fourth of the wood-lot area in the eastern half is in or adjacent to coal and gas regions, where the demand for firewood for local consumption is very small. For this reason it is estimated that over 50 per cent of the wood-lot area need not be depended upon to furnish the local supply of fuel. The demands of the farmer on the average wood lot for building material, fence posts, and other incidental timber uses on the farm are not very great in proportion to the total amount which the farmers' wood lots contain. At the present time a rather indiscriminate use is made of the timber in farmers' wood lots, and but little attention is paid to other than the immediate demand of the owner and to what material can be most easily secured to meet this demand. It is safe to say that, of the timber acreage alone, from 50 to 60 per cent could be safely counted upon to meet local demands other than those of the owners themselves.

The present rate of production of timber in farmers' wood lots does not exceed 30 cubic feet of wood per acre per year throughout the eastern half of the United States. In a great many sections the actual production of cubic feet per acre per year is exceedingly small, or perhaps nothing at all. This is because the wood lots in many cases contain a very high percentage of mature timber which has reached its maximum productive capacity, or because the farmers' wood lots are also used for pasturing and other purposes which greatly decrease the normal amount of annual production which would otherwise be obtained.

As a rule, farmers' wood lots may be said to occupy excellent sites for timber growing, as the character and fertility of the soil and the moisture which the soil contains are practically the same as that of the agricultural land on the remaining parts of the farms, and in many cases differ only from the remaining parts of the farms in being land which is too rough to cultivate. The unit of production on the wood lots in the eastern half of the United States should average from 60 to 70 cubic feet per acre per year. This would practically double the amount of timber which might be placed on the market over that which is now sold locally, while with greater care in the local use of the timber needed on the farm the amount of timber which might be placed on local markets would even be much greater.

Thus it will be seen that the relation which farmers' holdings bear to the total timber acreage in the country and the proportionate amount of timber with which they supply the local markets is very important, especially throughout the eastern half of the United States. Should their proportionate timber acreage slightly decrease every year, an increased production of over 100 per cent may be obtained on their future holdings. Wood-lot timber is cut more conservatively than the timber of other holdings in the East and may become a more important factor in the question of furnishing local timber supplies than it is at the present time. This demonstrates the very great need of more conservative and more intensive management of the timber land owned by the farmers in the United States.

This can only be brought about by the farmers themselves. They should be more thoroughly acquainted with the way in which to better care for and grow their timber supplies as well as the marketing of the timber which they now own.

Wood lots.

State	Total land area.	Area of woodland.	Per cent of woodland owned by farmers.	Area of wood lots.	Per cent of wood-lot area containing merchantable timber.	Area of wood lots containing merchantable timber.	Per cent of wood-lot area containing cordwood only.	Area of wood lots containing cordwood only.	Per cent of brush-land area in wood lots.	Area of brush land in wood lots.	Total stand of merchantable timber in wood lots.	Total stand of cordwood in wood lots.
	Acres.	*Acres.*		*Acres.*		*Acres.*		*Acres.*		*Acres.*	*Million feet b. m.*	*M cords.*
Maine	19,132,800	14,900,000	25	3,725,000	37	1,378,000	62	2,310,000	1	37,000	1,920	39,820
New Hampshire	5,779,840	3,500,000	51	1,785,000	36	643,000	41	732,000	23	410,000	778	10,220
Vermont	5,839,360	2,500,000	55	1,375,000	18	247,000	70	963,000	12	165,000	1,368	12,760
Massachusetts	5,144,960	2,000,000	75	1,500,000	35	525,000	41	615,000	24	360,000	1,050	9,235
Rhode Island	682,880	250,000	95	238,000	4	10,000	71	169,000	25	59,000	70	338
Connecticut	3,084,800	1,600,000	88	1,408,000	37	521,000	40	563,000	23	324,000	1,563	16,900
New York	30,498,560	12,000,000	59	7,080,000	30	2,124,000	55	3,894,000	15	1,062,000	8,590	2,561
New Jersey	4,808,960	2,000,000	62	1,240,000	37	459,000	49	608,000	14	173,000	450	4,825
Total	74,972,160	38,750,000	47	18,351,000	32	5,907,000	54	9,854,000	14	2,590,000	15,798	96,659
Delaware	1,257,600	350,000	66	231,000	42	97,000	53	122,000	5	12,000	364	547
Maryland	6,362,240	2,200,000	76	1,672,000	60	1,003,000	35	585,000	5	84,000	2,110	4,770
Virginia	25,767,680	14,000,000	82	11,470,000	39	4,473,000	52	5,965,000	9	1,032,000	13,160	43,700
Total	33,387,520	16,550,000	81	13,373,000	42	5,573,000	50	6,672,000	8	1,128,000	15,634	49,017
North Carolina	31,193,600	19,600,000	53	10,390,000	33	3,400,000	51	5,300,000	16	1,660,000	12,850	66,900
South Carolina	19,516,800	12,000,000	60	7,200,000	34	2,448,000	57	4,104,000	9	648,000	7,481	57,900
Georgia	37,584,000	22,300,000	70	15,820,000	43	6,810,000	48	7,590,000	9	1,420,000	22,000	21,625
Alabama	32,818,560	20,000,000	44	8,800,000	41	3,608,000	42	3,696,000	17	1,496,000	8,760	34,050
Florida	35,111,040	20,000,000	17	3,400,000	50	1,700,000	29	986,000	21	714,000	3,165	17,680
Mississippi	29,671,680	17,500,000	52	9,100,000	52	4,732,000	40	3,640,000	8	728,000	15,920	23,930
Louisiana	29,061,760	16,500,000	38	6,270,000	77	4,828,000	20	1,254,000	3	188,000	20,300	18,340
Texas	167,934,720	30,000,000	60	18,000,000	56	10,080,000	31	5,580,000	13	2,340,000	19,950	91,640
Total	382,892,160	157,900,000	50	78,980,000	48	37,636,000	40	32,150,000	12	9,194,000	110,426	331,965
Pennsylvania	28,692,480	9,200,000	53	4,875,000	29	1,414,000	57	2,779,000	14	682,000	2,820	38,570
West Virginia	15,374,080	9,100,000	43	3,910,000	37	1,447,000	44	1,720,000	19	743,000	7,092	21,080
Kentucky	25,715,840	10,000,000	74	7,400,000	38	2,812,000	54	3,996,000	8	592,000	8,260	21,100
Tennessee	26,679,680	15,000,000	72	10,800,000	44	4,752,000	45	4,860,000	11	1,188,000	15,160	30,500
Total	96,462,080	43,300,000	62	26,985,000	39	10,425,000	50	13,355,000	12	3,205,000	33,332	111,250

Wood lots—Continued.

State.	Total land area.	Area of woodland.	Per cent of woodland owned by farmers.	Area of wood lots.	Per cent of wood-lot area containing merchantable timber.	Area of wood lots containing merchantable timber.	Per cent of wood-lot area containing cordwood only.	Area of wood lots containing cordwood only.	Per cent of brush-land area in wood lots.	Area of brush land in wood lots.	Total stand of merchantable timber in wood lots.	Total stand of cordwood in wood lots.
	Acres.	*Acres.*		*Acres.*		*Acres.*		*Acres.*		*Acres.*	*Million feet b. m.*	*M cords.*
Ohio	26,073,600	4,800,000	97	4,655,000	50	2,328,000	37	1,722,000	13	605,000	3,808	27,560
Indiana	22,966,400	4,000,000	91	3,640,000	48	1,747,000	38	1,383,000	14	510,000	4,511	15,670
Michigan	36,787,200	15,500,000	30	4,650,000	37	1,720,000	45	2,093,000	18	837,000	6,100	35,900
Wisconsin	35,363,840	16,000,000	33	5,280,000	34	1,795,000	37	1,954,000	29	1,531,000	6,120	16,390
Minnesota	51,749,120	15,500,000	29	4,495,000	34	1,528,000	47	2,112,000	19	855,000	3,464	23,270
Total	172,940,160	55,800,000	40	22,720,000	40	9,118,000	41	9,264,000	19	4,338,000	24,003	118,790
Arkansas	33,616,000	24,200,000	44	10,650,000	61	6,500,000	35	3,730,000	4	420,000	13,220	32,400
Missouri	43,985,280	18,300,000	56	10,250,000	40	4,100,000	52	5,330,000	8	820,000	7,528	37,100
Total	77,601,280	42,500,000	49	20,900,000	51	10,600,000	43	9,060,000	6	1,240,000	20,748	69,500
Illinois	35,841,280	2,500,000	90	2,250,000	41	923,000	42	945,000	17	382,000	6,970	11,770
Iowa	35,575,040	2,500,000	94	2,350,000	31	729,000	50	1,175,000	19	446,000	530	2,162
Oklahoma	44,424,960	8,000,000	54	4,320,000	58	2,506,000	31	1,339,000	11	475,000	3,555	21,600
Kansas	52,335,360	1,000,000	95	950,000	5	47,000	80	760,000	15	143,000	704	6,080
Nebraska	49,157,120	800,000	97	776,000	3	23,000	85	660,000	12	93,000	22	4,620
North Dakota	44,917,120	600,000	100	600,000	2	12,000	73	438,000	25	150,000	12	3,508
South Dakota	49,195,520	1,200,000	25	300 000	2	6,000	73	219,000	25	75,000	6	1,751
Total	311,446,400	16,600,000	70	11,546,000	37	4,246,000	48	5,536,000	15	1,764,000	11,799	51,491
Total for eastern United States	....	371,400,000	52	192,855,000	43	83,505,000	45	85,891,000	12	23,490,000	231,740	828,672
Montana	93,296,640	18,000,000	2	360,000	95	342,000	3	11,000	2	7,000	1,676	34
Wyoming	62,460,160	10,000,000	1	100,000	98	98,000	1	1,000	1	1,000	1,243	6
Colorado	66,341,120	12,000,000	4	480,000	53	255,000	43	206,000	4	19,000	822	1,012
Idaho	53,618,560	20,000,000	2	400,000	97	388,000	2	8,000	1	4,000	5,560	44
Utah	52,597,760	6,000,000	5	300,000	69	207,000	25	75,000	6	18,000	913	395
Arizona	72,857,600	14,000,000	1	140,000	95	133,000	4	6,000	1	1,000	168	30
New Mexico	78,401,920	12,000,000	5	600,000	96	576,000	3	18,000	1	6,000	230	91
Nevada	70,285,440	5,000,000	1	50,000	96	48,000	3	1,500	1	500	48	8
Total	549,850,200	97,000,000	3	2,430,000	85	2,047,000	13	326,500	2	56,500	10,660	1,620

Washington	42,775,040	25,000,000	12	3,000,000	73	2,190,000	24	720,000	3	90,000	16,060	3,554
Oregon	61,188,480	27,000,000	10	2,700,000	87	2,349,000	9	243,000	4	108,000	41,280	1,142
California	99,898,880	24,000,000	16	3,840,000	86	3,302,000	12	461,000	2	77,000	11,480	2,187
Total	203,862,400	76,000,000	13	9,540,000	82	7,841,000	15	1,424,000	3	275,000	68,820	6,883
Total for western United States		173,000,000	7	11,970,000	83	9,888,000	14	1,750,500	3	331,000	79,480	8,503
Grand total	1,903,423,360	544,400,000	38	204,825,000	46	93,393,000	43	87,641,500	11	23,790,500	311,220	837,175

STAND OF TIMBER.

By **Herbert Knox Smith,**
Commissioner of Corporations.

The field work of the Bureau of Corporations on the quantity of standing timber covered those parts of Virginia, North Carolina, South Carolina, and Georgia, south and east of the mountains, and the timbered parts of the following States: Florida, Alabama, Mississippi, Louisiana, Texas, Arkansas, Missouri, Michigan, Wisconsin, Minnesota, Montana, Idaho, Washington, Oregon, and California.

The estimate of the total amount of privately owned merchantable standing timber on this entire area, obtained by the methods described below, on the basis of product of lumber under present conditions, is 1,570,000,000,000 board feet. The Forest Service has estimated the standing timber on the forest reserves at 390,000,000,000 board feet; that on the unappropriated public lands, national parks, and Indian reservations, 59,000,000,000 and that on the state lands, 35,000,000,000. These figures, together with that obtained by the Bureau of Corporations, give a total of about 2,050,000,000,000 board feet. No detailed investigation has been made for the privately owned timber outside the area covered by the Bureau of Corporations, but the Forest Service has made a tentative estimate of 450,000,000,000 feet for it, making the total standing timber in the United States about 2,500,000,000,000 board feet.

A systematic inquiry into the amount of standing timber in the United States might be made by either of two methods; first, to examine the entire timber area of the country and thus obtain the information first hand. This would require a very long time and great expenditure. Even if cost were disregarded it would be practically impossible to secure a sufficient number of experts to finish the task within a reasonable time.

The second method is that of bringing together the best information on the subject now in the records of timber owners or within the personal knowledge of men engaged in the industry. Nearly all owners of important tracts have fairly good knowledge of the quantity of their timber, and they, together with others engaged in the timber and lumber business, are acquainted with the other timber in their several localities. From such sources quite satisfactory estimates on the total timber in the entire county, or in certain parts of it, such as townships, or on the total timber exclusive of specified large holdings, can be obtained. Thus the facts regarding large holdings can be secured, and an estimate on all timber in the county outside such holdings separately reported can be had by interviewing the men best informed on the county as a whole or on subdivisions of it. A comprehensive plan by which all of this information is brought together and compared, and the most accurate data for the various localities tabulated gives the best information regarding the timber supply which can be obtained under present conditions at reasonable cost.

The general plan adopted by the Bureau of Corporations was to obtain first a report from each owner of 50,000,000 board feet or more. This report included, among other items, the acreage and an estimate of the amount of timber in as great detail as could be had, and, wherever obtainable, the exact location of the land. When this information had been obtained it was so arranged as to show for each county the names of owners, locations of lands, and estimates, and from this the work was carried forward by securing general estimates on the total of all other holdings in the county. The constant effort was to secure the information in as much detail as possible, so that each man's judgment could be taken on the area with which he was most familiar. Thus, wherever practicable, these general estimates were made for the timber in the county exclusive of the large holdings previously obtained, and were also taken for subdivisions of the county, such as survey townships or political subdivisions. In case it was not possible to secure an estimate on all small holdings in such detail, the estimate was obtained on the total timber in the county, but in no case did the estimate cover a larger area than a county, although some individuals furnished separate estimates for a number of counties. The judgment of as many well-informed men as could be found was obtained for each county. A final estimate for the county was then reached by a consideration of all the evidence.

The chief difficulty in arriving at the amount of timber owned by those having 50,000,000 board feet and over is that all estimates are largely a matter of judgment, and their accuracy depends on the care used and the skill of the man making the estimate. Good cruisers often differ very materially on the same tract. Again, nearly all estimates are too low because most obtainable estimates were made for the use of buyers whose first care was for a safe judgment on the value of the property. Such estimates run all the lower because in many instances the buyers have needed only rough and partial estimates to assure them that they were getting at least enough timber to make them safe at the price paid, with the probability that there was considerably more timber on the tract.

Another difficulty is due to changes in the standards of merchantable timber as the price of lumber advances. Vast quantities of timber now counted as merchantable would not have been so counted fifteen years ago, and in some parts of the country an estimate made in 1900 must be greatly increased to represent the timber which is now merchantable. With higher prices more logs are brought to the mill from the same tract, and the manufacturer of lumber will make more board feet out of the same log because he is able to sell some boards not previously marketable. Again, some species of timber formerly regarded as worthless are now valuable. Therefore, it has been necessary to bring estimates made a number of years ago up to date. The date of the estimate and the conditions surrounding it were always secured, and the owner was asked what increase, in his judgment, should be made for such correction.

In addition to the statements furnished by the owner, other men having knowledge of the land were interviewed, and in many instances valuable information was obtained from those not directly interested in the property.

The general estimates on all small holdings in a county or on the total timber in a county are subject to varying percentages of error because of the imperfect knowledge of the informants. And while it is believed that such estimates are oftener too small than too great, they are not always so, and, therefore, to some extent at least, the error in one county is offset by an opposite error in another county.

Estimates on standing timber are not usually meant to give the most probable approximation to the quantity of lumber which would be produced at the mill, but instead a conservative approximation to the scale of the logs if cut, on which there would be an overrun at the mill. This point has been studied on the basis of answers to specific questions and also of general interviews with the best informed men; and for the principal subdivisions of the timber area percentages have been determined by which the totals of the estimates have been increased to cover both the error in estimates, as such, and the overrun from good estimates to mill output. Consequently the final figures are the best judgment obtainable from the investigation on the amount of lumber which would be produced from the merchantable standing timber if sawed under the conditions now existing in the lumber industry. Without question, as the price of lumber advances, a very considerable addition will be made to the supply of timber through the lowering of the standards of merchantable timber and the better use of such logs as are now sawed, but there is now no basis upon which this additional amount can be approximated.

The field work was a long and difficult task, and the office work necessary to judge carefully all reports on the vast area covered to determine the most accurate figures in cases of conflicting statements, and finally to compile the records thus established, has been much greater than would be judged offhand. There is inevitable error in statistical data on standing timber, and the best that can be done is to gather the information in as much detail as possible and from as many people as have knowledge of definite areas, and through an impartial study of all this material to arrive at the best possible approximation to the truth. It is believed that the errors in the results of this investigation are not large enough to affect materially their value for the purposes which they serve.

STANDING TIMBER OWNED BY THE STATES.

By J. Girvin Peters,
United States Forest Service.

The information regarding the stand of timber owned by individual States was obtained from state foresters and other state officials, and in a few cases from Forest Service officials. In many States the knowledge of the amount of timber owned is extremely meager, and the information furnished by a large majority was simply an estimate.

The total estimated amount of standing timber owned by the different States is 35,474,050,000 board feet, and the total area of State land forested is 9,460,622 acres.

The largest amount of timber owned by any State is that reported for New York, which is 8,600,000,000 board feet. Of the total amount reported by all the States, less than 10 per cent is hardwood. The bulk of the timber owned by the States located in the northern forest is spruce, white and Norway pine, hemlock, and cedar; in the southern forest, yellow pine; in the Rocky Mountain forest, western yellow pine, and in the Pacific coast forest, Douglas fir and redwood. The quality of the bulk of this timber is good, but not the best.

The following table shows the estimated amount of timber and forest land owned by the different States and Territories:

Estimated amount of standing timber and area of forest land owned by the different States and Territories.

State or Territory.	Amount.	Area forested.
	M feet B. M.	*Acres.*
Arizona	735,000	200,000
Arkansas	50,000	25,400
California	5,400,000	915,700
Colorado	680,000	572,800
Florida	625,000	250,000
Idaho	3,800,000	144,200
Maryland	250	1,957
Massachusetts	2,400	12,000
Michigan	480,000	120,000
Minnesota	2,519,900	2,695,187
Mississippi	170,000	180,800
Montana	1,158,900	1,000,000
Nevada	4,000	4,000
New Jersey	4,600	9,900
New Mexico	620,000	277,800
New York	8,600,000	1,599,638
North Carolina	225,000	125,000
Oklahoma	14,000	14,000
Oregon	5,000,000	502,840
South Dakota	125,000	59,400
Washington	5,000,000	500,000
Wyoming	260,000	250,000
Total	35,474,050	9,460,622

STANDING TIMBER IN POSSESSION OF THE FEDERAL GOVERNMENT.

By G. M. Homans,
United States Forest Service.

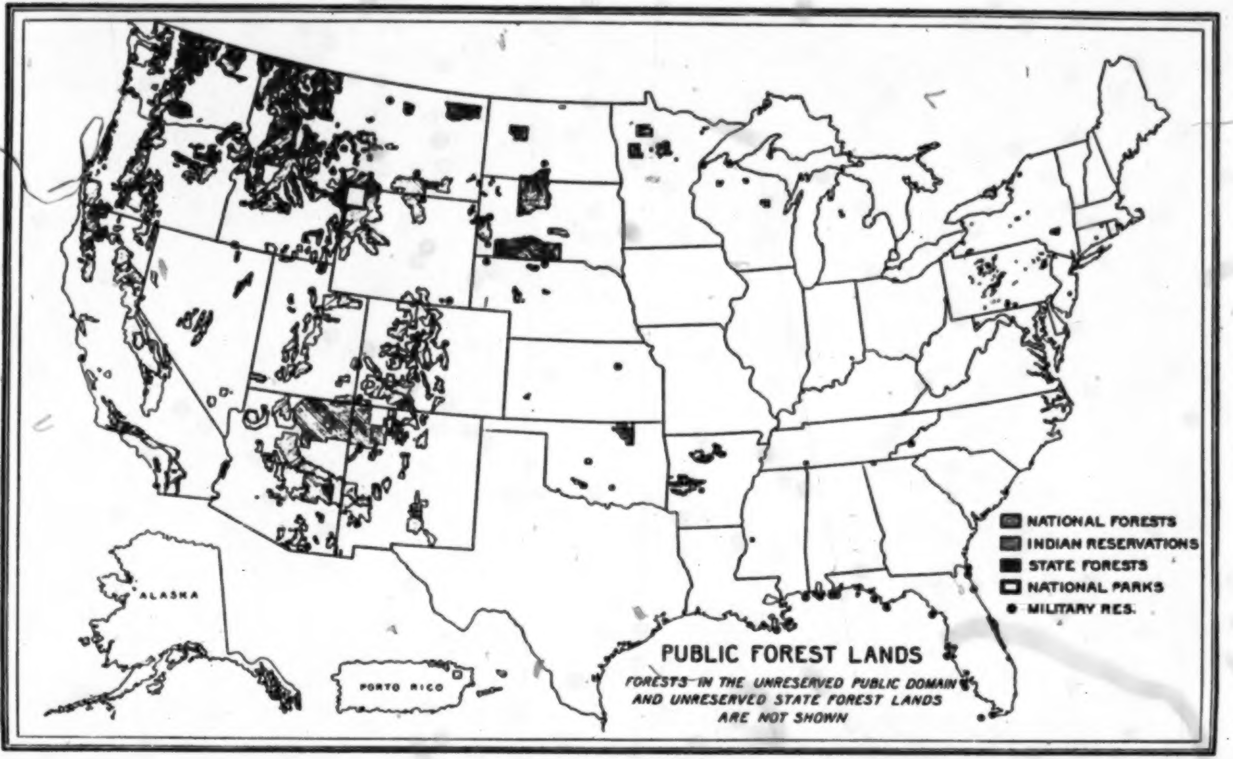
The estimated amount of merchantable timber in the possession of the Federal Government, exclusive of Alaska, in its National Forests, Indian reservations, national parks, military reservations, and on unreserved public lands, is nearly 449,000,000,000 feet, b. m., and an unestimated amount of cord-wood, poles, posts, and mining timbers. Of this amount, over 86.7 per cent is within the national forests, 7.6 per cent within the Indian reservations, and over 3 per cent on the unreserved public lands. This material resource has an average value of $2.50 per thousand feet and represents a capital of $1,122,150,000.

The actual forested area now containing merchantable saw timber is approximately 92,629,500 acres, of which 81 per cent is national forests, 11 per cent Indian reservations, and 5 per cent unreserved public lands (Table 2).

In the Pacific coast region the stand per acre is much the heaviest and decidedly more variable. On the west slope of the Cascade Range selected acres of Douglas fir will often exceed 100,000 feet b. m., while on the east slope, in the yellow pine country, areas not exceeding 4,000 feet b. m. are very common. The average stand per acre is more uniform in the Rocky Mountain and eastern region since the forested area is comprised largely of pure stands and of species more uniform in volume.

The principal merchantable species in the Pacific coast region are, in the order of their predominance, Douglas fir, western yellow pine, white fir, hemlock, sugar pine, tamarack, redwood, and lodgepole pine. In the Rocky Mountain region the species having the greater commercial value are, in the order of their occurrence, lodgepole pine, yellow pine, Engelmann spruce, white fir, Douglas fir, western white pine, and cedar. The remaining merchantable area, with the exception of Arkansas and Minnesota, lies east of the Mississippi River, and the stand is composed chiefly of white pine, long-leaf and short-leaf pine, white oak, red oak, chestnut, basswood, birch, white ash, cypress, and other mixed hardwoods.

Although it is impossible to state accurately the amount of the more important species, yet it is estimated that the stand is composed of 30 per cent western yellow pine, 20 per cent Douglas fir, 10 per cent lodgepole pine, 7 per cent white fir, 5 per cent Engelmann spruce, 5 per cent western hemlock, 5 per cent cedar, 3 per cent tamarack, 3 per cent sugar pine, and 12 per cent of other species. Since the mixed hardwoods form such a small part of the total stand, they have been included in the percentages for other species.


NATIONAL FORESTS
INDIAN RESERVATIONS
STATE FORESTS
NATIONAL PARKS
MILITARY RES.
ALASKA
PORTO RICO

PUBLIC FOREST LANDS

FORESTS IN THE UNRESERVED PUBLIC DOMAIN AND UNRESERVED STATE FOREST LANDS ARE NOT SHOWN

FIG. 2.

Generally speaking, the quality of the timber in the possession of the Federal Government compares unfavorably with that in the possession of large companies and corporations. This is easily accounted for, since a large part of the unappropriated area lies at high altitudes, which are unsuited for the best growth and development of the several species.

The national forests comprise a merchantable timber area of 75,030,000 acres and support a stand of approximately 390,000,000,000 feet b. m.

The Indian reservations comprise a merchantable timbered area of 10,541,900 acres and contain approximately 34,000,000,000 feet b. m. On the whole, the timber on Indian reservations consists chiefly of yellow pine, piñon, and juniper, and is of better quality than that in the national forests, since these reservations have been created at the lower elevations and have included land better adapted for the most favorable growth.

The merchantable area of national parks is estimated to be 2,540,000 acres and contains 10,717,000,000 feet b. m. and 343,500,000 cords of wood suitable only for fuel. The kind and quality of the timber is similar to that in national forests, since they have been created in similar regions and in large part include areas at and above timber line.

Military reservations, in so far as they contain natural timber resources, are of practically no importance, since they have a merchantable area of but a little over 69,000 acres, supporting but 198,595,000 feet b. m. and 3,900,000 cords of wood suitable chiefly for fuel. The stand is composed chiefly of longleaf and shortleaf pine, Douglas fir, white fir, and mixed hard-woods. On the whole, the several species contain but little lumber of the high grades, which renders them useless for other than fuel and rough construction material.

There are approximately 4,450,000 acres of unreserved public timber land which supports approximately 14,000,000,000 feet b. m. and an unestimated amount of cordwood. This figure seems somewhat startling when one realizes that unappropriated timber land is not only subject to entry but is very much sought after on account of the diminishing supply and a corresponding increase in stumpage prices, yet it must be understood that the areas supporting this timber are in many instances so surrounded by patented land that a claim would be practically worthless for lumbering purposes, while in other cases the tracts are either too inaccessible or are of insufficient size to attract the average claimant. Since these timbered areas have thus far been rejected by claimants it follows naturally enough that this is practically the cull of the Government's national timber resources. The stand is open, scattered, and scrubby for the most part, and consists chiefly of the poorer quality of Douglas fir, hemlock, white fir, juniper, piñon, cedar, and lodgepole pine.

TABLE 1.—*Estimated amount of standing timber in the possession of the Federal Government.*

State.	National forests.	Indian reservations.	National parks.	Military reservations.	Unreserved public lands.	Total.
	M feet b. m.	*M feet b. m.*	*M feet b. m.*	*M feet b. m.*	*M feet b. m.*	*M feet b. m*
Alabama				1,500	50,000	51,500
Arizona	6,500,000	5,000,000		50,000		11,550,000
Arkansas	1,800,000				634,000	2,434,000
California	94,800,000	3,500,000	8,000,000		3,216,000	109,516,000
Colorado	12,200,000				1,200,000	13,400,000
Florida				8,400	80,000	88,400
Georgia				4,100		4,100
Idaho	34,000,000	2,000,000			2,000,000	38,000,000
Indiana				75		75
Kansas				4,640		4,640
Louisiana					55,000	55,000
Maine				220		220
Maryland				510		510
Michigan					36,000	36,000
Minnesota		3,200,000			500,000	3,700,000
Mississippi					21,000	21,000
Missouri					13,000	13,000
Montana	35,900,000	2,400,000		12,000	1,200,000	39,512,000
Nebraska					10,000	10,000
Nevada	75,000				100,000	175,000
New Mexico	11,200,000	1,700,000		40,000	800,000	13,740,000
New York				570		570
North Carolina				30		30
Oklahoma	18,000	4,000,000				4,018,000
Oregon	90,075,000	3,900,000	562,000	600	2,500,000	97,037,000
South Dakota	2,256,000	75,000			443,000	2,774,000
Utah	5,940,000	14,000			300,000	6,254,000
Virginia				50		50
Washington	89,954,000	6,100,000	1,475,000	75,000	672,000	98,276,000
Wisconsin		2,000,000			8,000	2,008,000
Wyoming	4,700,000	200,000	680,000	900		5,580,900
Total	390,018,000	34,089,000	10,717,000	198,595	13,838,000	448,860,595

TABLE 2.—*Estimated area of merchantable saw timber held by the Federal Government.*

State.	National forests.	Indian reservations.	National parks.	Military reservations.	Unreserved public lands.	Total.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Alabama				1,700	25,000	26,700
Arizona	5,000,000	3,000,000		15,400		8,015,400
Arkansas	916,000			780	317,000	1,233,780
California	14,000,000	209,000	500,000	517	804,000	15,513,517
Colorado	6,310,000		30,000		400,000	6,740,000
Florida				2,241	40,000	42,241
Georgia				1,270		1,270
Idaho	8,964,000	190,000			500,000	9,654,000
Illinois				200		200
Indiana				588		588
Iowa				184		184
Kansas				4,800		4,800
Louisiana				355	22,000	22,355
Maine				105		105
Maryland				315		315
Michigan		15,500			30,000	45,500
Minnesota	147,000	800,000			300,000	1,247,000
Mississippi					8,500	8,500
Missouri				1,708	5,000	6,708
Montana	8,000,000	655,000		1,500	300,000	8,956,500
Nebraska				7,500	20,000	27,500
Nevada	75,000					75,000
New Jersey				1,357		1,357
New Mexico	5,000,000	600,000		8,000	400,000	6,008,000
New York				3,096		3,096
North Carolina				1,340		1,340
North Dakota		20,000	600			20,600
Oklahoma	18,000	2,000,000	200			2,018,200
Oregon	10,700,000	915,000	140,000	340	546,000	12,301,340
South Carolina				50		50
South Dakota	800,000	75,000	3,500	65	443,000	1,321,565
Tennessee			4,993			4,993
Texas				1,710		1,710
Utah	3,000,000	13,400			200,000	3,213,400
Vermont				20		20
Virginia				27		27
Washington	7,600,000	1,694,000	126,720	13,981	84,000	9,518,701
Wisconsin		315,000			4,000	319,000
Wyoming	4,500,000	40,000	[a] 1,734,000			6,274,000
Total	75,030,000	10,541,900	2,540,013	69,149	4,448,500	92,629,562

[a] Includes small portions of the Yellowstone in Montana and Idaho.

FOREST PRODUCTS.

By R. S. Kellogg.
United States Forest Service.

The annual value of the forest products of the United States at the present time is approximately $1,280,000,000. The principal items are shown below; the value in every case is stated in round numbers and is estimated at the point of production. Except where otherwise specified, all statistics given in this paper are based upon data collected by the Bureau of the Census and the Forest Service.

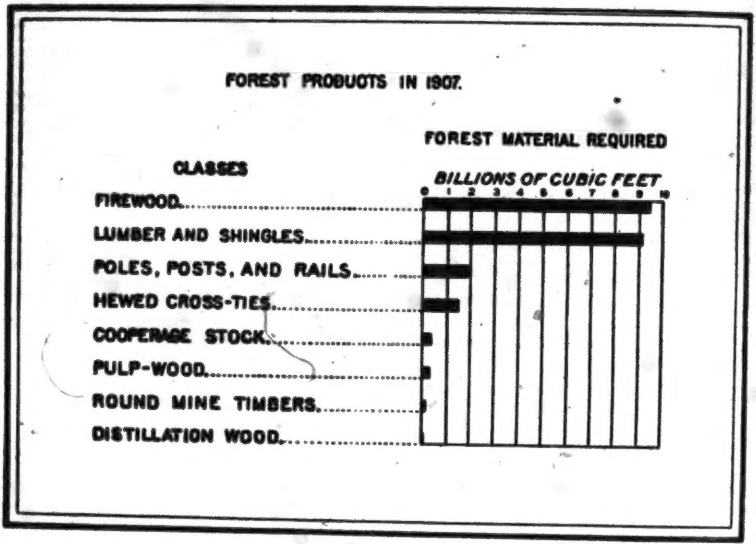


FIG. 1.

Product.	Value.	Product.	Value.
Lumber, shingles, and lath	$750,000,000	Pulp wood	$20,000,000
Firewood	250,000,000	Tanbark and extracts	15,000,000
Poles, posts, and rails	100,000,000	Round mine timbers	10,000,000
Hewed cross-ties	60,000,000	Miscellaneous	10,000,000
Cooperage stock	35,000,000		
Naval stores	30,000,000	Total	1,280,000,000

Nearly three-fifths of the total value of our forest products are made up of lumber, shingles, and lath, and a little less than one-fifth of firewood. No other group of products contributes as much as 10 per cent of the total.

The quantity of forest material required for these products under present conditions of logging and manufacturing is shown graphically in figure 1. The total exceeds 23,000,000,000 cubic feet. Of this, firewood takes about two-fifths, lumber and shingles slightly less, posts, poles, and rails about one-twelfth, and hewed cross-ties about one-sixteenth; relatively small quantities compared with the total cut of forest material required for other products.

LUMBER.

The cut of lumber, by kinds, in 1907, is shown graphically in figure 2, the total being 40,256,000,000 board feet. Yellow pine was in the lead, with 32.8 per cent of the total; Douglas fir ranked second, with 11.8 per cent; white pine third, with 10.4 per cent; oak, fourth, with 9.2 per cent; and hemlock fifth, with 8.4 per cent. Spruce and western pine furnished 4.3 and 3.8 per cent, respectively. These seven woods are the only ones from which over a billion feet of lumber are annually produced, and, taken together, they furnish more than four-fifths of our annual lumber supply.

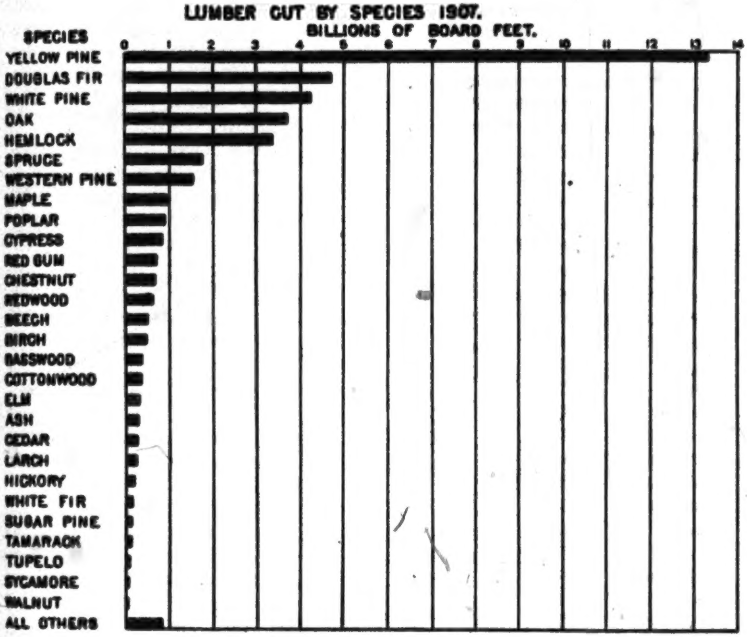


FIG. 2.

The softwoods as a group supplied 77 per cent of the lumber cut in 1907, and the hardwoods 23 per cent. The softwood cut, therefore was nearly three and one-half times as great as the hardwood cut. Though there was an increase of over 14 per cent in the total lumber production from 1900 to 1907, this was due chiefly to very heavy increases in the leading soft woods, particularly yellow pine and Douglas fir. At the former date the hardwoods supplied nearly 25 per cent of the total. During the seven years the output of yellow pine increased 36.8 per cent, that of western pine 61.7 per cent, that of cypress 52.8 per cent, that of redwood 58 per cent, and that of Douglas fir 173.4 per cent. These far more than counterbalanced the decrease of 45.8 per cent in white pine. On the other hand, the cut of the two leading hardwoods, oak and yellow poplar, decreased 16.2 per cent and 22.6 per cent, respectively, during this period. Remarkable increases took place in the output of some of the minor hardwoods, the gain in maple, for instance, being 48.4 per cent, in red gum 141.5 per cent, and in chestnut 215.5 per cent.

The lumber cut by States in 1907 is shown in figure 3. Washington, which ranked first, supplied 9.4 per cent of the total; Louisiana came second, with 7.4 per cent; Texas third, with 5.5 per cent; Mississippi fourth, with 5.2 per cent; and Wisconsin fifth, with 5 per cent. These five States are the only ones which cut two billion or more feet of lumber each in 1907, and taken together they furnished nearly one-third of the total production.

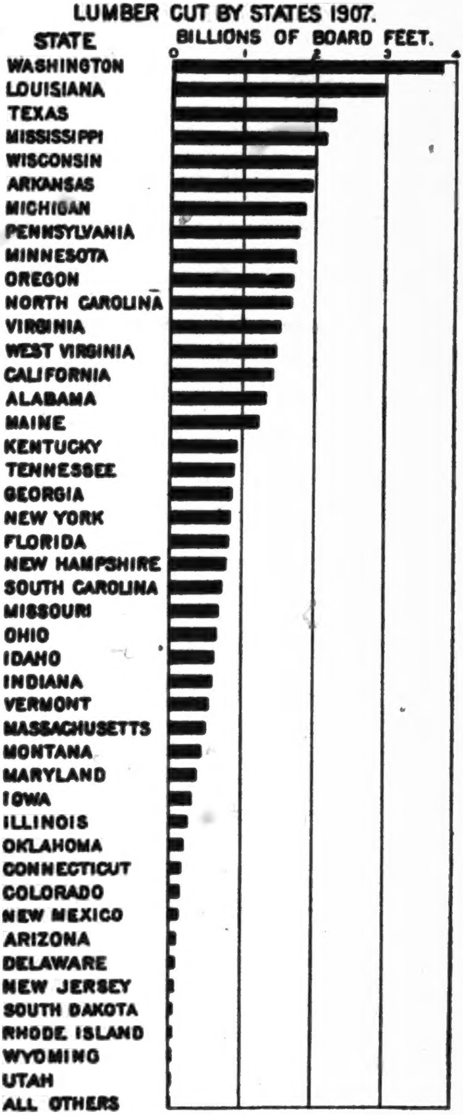


Fig. 3.

The relative production of lumber in ten States in 1880 and 1907 is shown in figure 4. In 1880 these States furnished 53.8 per cent of the total cut, and in 1907, 52.4 per cent, practically equal proportions, but the changes which have occurred in the output of individual States are most striking. Michigan, for example, furnished 23 per cent of the total in 1880, and but 4.5 per cent in 1907; Louisiana supplied but 0.7 per cent of the total in 1880, and 7.4 per cent in 1907; Washington cut but 0.9 per cent of the total in 1880, and 9.4 per cent in 1907. This diagram shows in vivid fashion the manner in which, with the cutting out of the virgin timber in the North and East, we have turned to the forests of the South and West for our lumber.

Figure 5 shows graphically the lumber production of the United States at census dates, from 1850 to 1907. The cut in 1907 was eight times that in 1850, and three times that in 1870. Notwithstanding the introduction of substitutes for lumber, our use of it has steadily increased up to the present time, the per capita consumption in 1850 being but 215 board feet, while in 1907 it was 470 board feet.

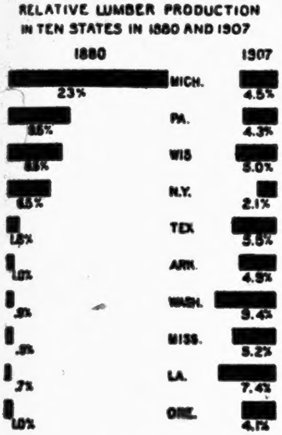


FIG. 4.

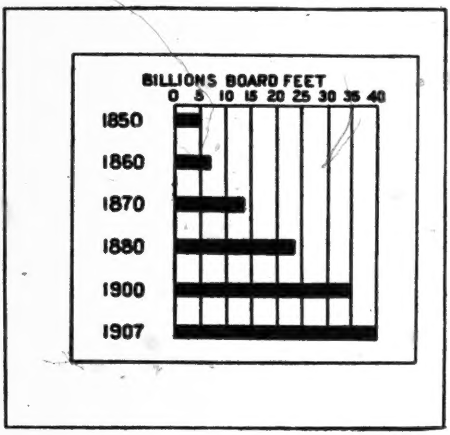


FIG. 5.

SHINGLES.

Many woods are used to some extent for shingles, but the market is dominated by cedar shingles, of which there are two kinds, the white cedar, or arbor-vitæ of the northeastern and Lake States, and the so-called "red cedar," or giant arbor-vitæ of the Pacific coast. Of the total production of 11,824,475,000 shingles in 1907, the western cedar supplied over three-fifths and the eastern cedar about one-tenth. Ten per cent of the shingles manufactured that year were of cypress, and 7 per cent and 5 per cent, respectively, of redwood and yellow pine. Much more cedar is used for shingles than for other purposes, while with other woods shingles are frequently a by-product of lumber manufacturing.

LATH.

Lath are usually a by-product of lumber manufacturing, and so do not of themselves constitute an additional drain upon the forests. While some lath are made from nearly every wood that is cut into lumber, the bulk of the 3,663,000,000 lath manufactured in 1907 was of white pine, yellow pine, hemlock, Douglas fir, spruce, and cypress.

FIREWOOD.

It is estimated that approximately 100,000,000 cords of wood, exclusive of mill waste, are used annually for fuel in the United States. The bulk of this is, of course, used for domestic purposes upon farms in the regions where wood is relatively cheap and abundant and coal difficult to obtain or high in price. A great deal of wood is used for fuel everywhere except on the Great Plains, where the almost utter absence of timber makes its use impossible. Much of it is cut from farmers' wood lots, and much of it is timber which has little value for other purposes. On the other hand, it is not uncommon to find good hard-wood timber which could be used for lumber or otherwise cut into firewood.

POLES, POSTS, AND RAILS.

Some 3,500,000 round poles, exceeding 20 feet in length, are used annually by telegraph, telephone, and other electric companies. Over three-fifths of these poles are of cedar and more than one-fourth of them of chestnut. Relatively small amounts of pine, cypress, and redwood poles are also used.

Probably 1,000,000,000 fence posts and rails are used annually upon the farms and ranches in the United States. While the cedar posts of the Lake States are shipped long distances, most of the posts and practically all of the fence rails are cut in the locality where they are used. Consequently, the timber of which they consist varies greatly, the effort always being, of course, to cut the kind that is the most durable. Wherever it grows, chestnut is a favorite wood for both posts and rails. Many posts are made from young, round timber. Rails are generally made from straight timber, of larger size, which splits well, and many posts are also split.

HEWED CROSS-TIES.

The steam and electric railway companies of the United States purchased more than 153,0[illegible],000 cross-ties in 1907, over three-fourths of which were hewed. Since sawed cross-ties are classed as lumber, they are not discussed here. The oaks, and chiefly the white oaks, supply over 45 per cent of the hewed ties, and the cutting of hewed ties from young oak trees is, with the exception of lumber, the most serious drain upon our oak forests. Over 22 per cent of the hewed cross-ties were supplied by the southern pines, about 7 per cent by cedar, and about 5 per cent by chestnut. Spruce, tamarack, western hemlock, and redwood are used in lesser quantity for hewed ties.

PULP WOOD.

Over 3,000,000 cords of domestic pulp wood were used in 1907, and in addition some 925,000 cords were imported from Canada. Of the domestic pulp wood, nearly three-fifths were spruce and almost one-fifth hemlock. The bulk of the remainder was poplar, with small quantities of several other woods. Nearly as much spruce is used for pulp as for lumber.

COOPERAGE STOCK.

Cooperage stock is of two distinct classes, tight and slack. While the production of the former is much less in quantity, it requires much higher grade timber. In 1907 there were manufactured 385,232,000 tight staves and 27,692,994 sets of tight heading. The slack cooperage output amounted to 1,175,977,000 staves, 106,074,000 sets of heading, and 490,570,000 hoops. Probably 90 per cent of the tight cooperage stock required the best quality of white oak for its production. A large number of woods are used for slack staves and heading, the most important being red gum, pine, elm, beech, and maple. Because of its strength and toughness, little but elm is used for hoops. Probably as much elm is used for staves and hoops as for lumber.

TANBARK AND EXTRACTS.

The tanneries of the United States used nearly 1,200,000 cords of hemlock and oak bark and more than 400,000 barrels of tanning extracts made from domestic bark and wood in 1907. Two-thirds of the bark was hemlock, and the balance oak. Two-thirds of the extract was made from chestnut wood, and most of the remainder from hemlock and oak bark. Nearly 130,000 cords of hemlock and oak bark were used in making extract.

In the earlier days of the tanning industry a great deal of hemlock was cut solely for its bark and the wood was left to rot in the woods. This was also true to a lesser extent of oak. These practices are not general at the present time, however. The manufacture of tanning extract from chestnut wood has increased rapidly within recent years, and at least 250,000 cords of wood were used for this purpose in 1907. There have also been marked increases in the importation of tanning materials, the most striking being that of the wood and extract of quebracho, a South American tree. Over 290,000 barrels of quebracho extract were used by the tanneries of the United States in 1907.

ROUND MINE TIMBERS.

Data gathered by the Forest Service and the Geological Survey in 1905, upon the use of timber in mines, show that the annual consumption of round mine timbers exceeds 165,000,000 cubic feet, and that hard woods consitute more than half the total. Like the making of hewed cross-ties, the cutting of round mine timbers takes large quantities of young timber, and in many localities constitutes a serious drain upon the forests.

NAVAL STORES.

In 1908 there were produced 36,000,000 gallons of turpentine and 4,000,000 barrels of rosin, of which Georgia and Florida supplied two-thirds. About one-half of the product is exported.

While the production of naval stores does not necessarily destroy the forests, the methods so far used in the majority of the turpentining operations, coupled with subsequent fires and windstorms, have resulted in the destruction of not less than 20 per cent of the forests worked.

MISCELLANEOUS PRODUCTS.

There are included under this heading such forest products as maple sugar and sirup, timber which is exported in the log, and wood used for distillation, whose total annual value is easily $10,000,000. More than 1,280,000 cords of wood were used for distillation in 1907. With the exception of about 60,000 cords of pine, this wood consisted of hard woods, chiefly birch, beech, and maple. No detailed information is available upon either the kind or quantity of logs exported, though the reports of the Bureau of Statistics show their value to be more than $3,000,000. Probably more walnut is exported in the log than any other timber which is sent out in this form.

RATE OF FOREST GROWTH.

By E. A. ZIEGLER,
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PRESENT TIMBER PRODUCTION.

The very existence of a problem of forest conservation is dependent upon the question of timber production. If production falls below consumption at present or threatens to in the future, the problem is very real. If the production exceeds consumption there is obviously no problem of conservation to solve. What data we have, therefore, on tree growth and wood production deserve careful study.

An idea of our present timber production requires, in the absence of records, information (1) on the rate of growth in diameter and height of the individual species composing our forests; (2) on the production per acre when a normal number of trees is present (i. e., when the land is fully stocked), and (3) on the condition for growth of the present forest. This (3) requires the classification of forest lands roughly into (*a*) nonproducing forest land which includes that covered with mature forests, as well as that not producing through lack of trees, and (*b*) the producing forest land with its present stocking, whether cut over, culled over, or burned. Applying the average growth per fully stocked area to the area of producing forest and multiplying by the average per cent of stocking would give the total growth. It is very difficult to secure definite data showing the average restocking of second-growth forests of the country, however, and on this point it may be necessary to accept expert judgment supported by studies of specific areas.

THE RATE OF GROWTH OF INDIVIDUAL SPECIES.

Studies on the rate of growth of different species giving the diameter and height at different ages have been made and are here summarized. These studies were largely made on trees cut in virgin forests, where their development under the shade of a preceding generation of trees may have been slower than if they had been given the better light conditions of a clearing or heavy culling. To what degree the changed condition of light, soil, etc., following lumbering affects subsequent growth is not definitely known,[a] though the diameter growth of individual trees is frequently increased, but often a poorer quality of material is produced. This is caused to some extent by too few trees per acre, which reduces the acre yield in the face of faster diameter growth in the individuals.

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[a] The increased growth due to removing mature trees in a spruce forest in New York was found to be about 13 per cent for the first five years after lumbering.—"The Adirondack Spruce," page 45, Pinchot.

The growth given is of course an average. White pine on lower slopes in New York is said to have an average diameter of 10.6 inches in fifty years. The largest number will be from 9 to 12 inches in diameter, though a few may be 15 inches or even more, and many trees will fall much below that figure.

The summaries are grouped in the form of regional tables:

Table 1, showing diameter and height growth in northern forests.

Table 2, showing diameter and height growth in central hard-wood forests.

Table 3, showing diameter and height growth in southern forests.

Table 4, showing diameter and height growth in Rocky Mountain forests.

Table 5, showing diameter and height growth in Pacific coast forests.

Both the common and botanical names are given, as well as the locality and so-called forest type where the measurements were made. The diameter and height at different ages follow.

Different studies made on the same species show varying rates of growth, so to avoid the bulky mass of detail a selection was made of the more representative data and the rest added in an appendix. When only one study was made, and the growth hardly seems representative of the species, note is made of it.

A study of the tables will reveal large differences in rate of growth in diameter and height between different species, but a full comparison should include the number of trees per acre also. That is, the production per acre must be the final index in determining desirable species, rather than rapidity of diameter or height growth which may be offset to some extent by the stand per acre.

TABLE 1.—*Approximate average rate of growth for northern forests.*

Species.		Locality.	Forest type.	Age.											
				30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
Common name.	Botanical Name.			Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Arborvitæ	Thuja occidentalis	Michigan	Swamp	2.2	15	3.8	28	5.7	34	6.9	38	9.8	45	12.3	50
Aspen	Populus tremuloides	Maine	Mixed hardwood	6.0	45	9.4	65	12.0	76						
Basswood	Tilia americana	Michigan	do	4.5	42	8.1	51	13.2	67	15.7	72	19.1	75		
Beech [a]	Fagus atropunicea	do	do	1.8	19	3.8	35	8.0	68	10.2	73	13.6	74	16.6	75
Birch, paper	Betula papyrifera	Maine	Paper birch—Seedling	5.3	44	8.0	62	10.2	78						
		New Hampshire	Paper birch—Sprout	5.6	49	7.9	70								
Birch, yellow	Betula lutea	New York	Mixed hardwood	2.6	24	4.5	35	7.4	52	9.4	59	14.5	69	19.4	75
Elm, white	Ulmus americana	No data													
Fir, balsam	Abies balsamea	New York	Dry swamp	2.3	20	5.2	42	7.2	53	7.6	54	8.3	57		
Hemlock [a]	Tsuga canadensis	Michigan	Hemlock-hardwood	1.3	9	2.9	20	5.7	37	7.8	45	13.4	63	18.4	73
Maple, sugar [a]	Acer saccharum	do	Mixed hardwood	1.9	21	3.8	35	7.0	50	9.0	64	14.0	72		
Pipe, jack	Pinus divaricata	Minnesota	Jack pine—Quality I	6.2	40	8.5	50								
Pine, red	Pinus resinosa	Wisconsin	Ravine—Quality I	5.8	45	10.3	75	15.3	90	17.6	95	22.6	108	26.1	108
Pine, white	Pinus strobus	New York	Lower slopes	5.8	42	10.6	60	16.6	82	20.0	92	26.0	106	29.8	115
		Minnesota	White and red pine	5.3	48	9.2	71	13.0	82	14.8	85	18.3	91	21.7	96
Spruce, black	Picea mariana	Minnesota	Swamp			1.1	9	2.6	17	3.0	20	4.1	26	4.7	29
Spruce, red	Picea rubra	Maine	Spruce slope	2.4	21	5.3	36	7.2	44						
Spruce, white	Picea canadensis	Minnesota	Swamp			2.3	22	4.9	41	6.0	46	9.0	60		
Tamarack	Larix laricina	do	do	2.9	32	5.0	50	6.9	62	7.8	66	11.0	75		

[a] These species were undoubtedly suppressed for some years.

NOTE.—The diameter given is 4.5 feet from the ground.

NORTHERN FORESTS.

This region embraces New England, New York, and the lake States of Michigan, Wisconsin, and Minnesota, and part of the Appalachian highlands extending farther south. It is marked by the presence of the white pine as the principal species. Red spruce in the east, red pine in the west, and hemlock through a large part of the region are important conifers, with arborvitæ, tamarack, and jack pine of less importance. Birches, beech, elm, aspen, basswood, and maples are rather important hard woods.

In growth, white pine leads except for jack pine and aspen in the first thirty years. Red pine in Wisconsin and Minnesota seems to exceed it in that part of the range with an excellent growth. Since jack pine is a small tree when mature its growth falls off rapidly before reaching even tie size. Spruce is rather slow growing, but arborvitæ, tamarack, hemlock, and balsam fir are still slower. Aspen and basswood grow rapidly, as does paper birch under favorable conditions. Beech, sugar maple, and yellow birch are rather slow growing. The figures for beech, hemlock, and sugar maple seem to show a suppression during early life, and further studies under different conditions may show a more rapid growth, though at best they grow slowly.

CENTRAL HARD-WOOD FORESTS.

The central hard-wood forests are found mainly on the west and east slopes of the Alleghany Mountain plateau. They have been largely removed from Illinois and Indiana, so Tennessee and Kentucky show their best development at present. Yellow poplar is the most rapid-growing species and furnishes a good example of growth, as it varies under different conditions of virgin forest and second growth, the latter under very favorable conditions. Chestnut is a very rapid grower and has next place. Since valuable for posts, poles, and ties in small sizes, it holds forth great promise to the wood producer. Red oak, black oak, and white oak follow in the order named when grown from sprouts. Hickory approaches white oak in growth.

Farm timber plantations in Illinois show an excellent growth for silver maple for fuel, catalpa and European larch for posts and poles, and black walnut, under an eighty to one hundred year rotation, for timber.

TABLE 2.—*Approximate average rate of growth for central hardwood forests.*

Species.		Locality.	Forest type.	Age.[a]											
				30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
Common name.	Botanical name.			Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Catalpa[a]	Catalpa speciosa	Illinois	Farm plantations	9.0	45										
Chestnut	Castanea dentata	Maryland	Hardwood, seedling	6.0	33	11.2	64	17.2	84	20.1	91				
			Hardwood, sprout	9.3	57	13.4	77	18.0	90	19.8	93				
Mockernut (hickory).	Hicoria alba	Mississippi	Mixed hardwood	3.3		6.0		10.5		13.3		20.0		26.0	
Larch, European.[a]	Larix europea	Illinois	Farm plantations	8.8	45										
Locust, black	Robinia pseudacacia	Kentucky	Close to open stands	7.1	36	11.5	44								
Maple, silver[a]	Acer saccharinum	Illinois	Farm plantations	9.0	55										
Oak, black	Quercus velutina	Tennessee	Mixed hardwood, seedling.	4.8	35	7.8	52	12.0	61	14.2	68	18.3	78	22.0	85
		Kentucky	Mixed hardwood, sprout.	6.9	53	11.3	75	13.8	80	14.4	81				
Oak, chestnut	Quercus prinus	Tennessee	Mixed hardwood, seedling.	3.3	20	5.6	35	8.8	45	11.0	53	16.0	66	21.0	76
Oak, red	Quercus rubra	Kentucky	Mixed hardwood, sprout.	7.6	56	12.4	76	16.4	86						
Oak, white	Quercus alba	Tennessee	Mixed hardwood, seedling.	3.5	27	5.8	34	9.0	56	11.2	65	17.0	82	22.2	92
		Kentucky	Mixed hardwood, sprout.	5.6	40	8.7	57	11.2	69	12.2	72	14.4	77		
Walnut, black[a]	Juglans nigra	Illinois	Farm plantations (moist soil).	8.0	40	12.0	60								
Yellow poplar	Liriodendron tulipifera	Tennessee	Cove (virgin forest)	5.0	39	8.7	60	13.7	81	17.0	90	24.0	100	28.2	105
		Virginia	Second growth in open—Quality I—seedling.	9.7	64	15.2	83								

[a] These species were grown in plantations on farm land, and have a correspondingly faster growth than the other forest-grown species. (See For. Ser. Cir. 81.)

NOTE.—The diameter given is 4.5 feet from the ground.

SOUTHERN FORESTS.

Southern forests include mainly the southern pine belt and the hard woods found along the rivers and coast, where cypress adds another important conifer.

The three principal southern pines, longleaf, shortleaf, and loblolly, make up the bulk of the southern forests and should play an important part in the future timber production of the country. Loblolly grows very rapidly and will produce a good crop of ties in forty years. Longleaf and shortleaf are both much slower growers, though longleaf gives excellent reproduction where fires do not run. Shortleaf occasionally exceeds longleaf in growth. The restocking of the cut-over pine forests is especially deficient on account of fire. Cypress makes a rather slow growth at first, but increases it to a considerable age, so that for a long period rotation it exceeds many other species. The natural reproduction is almost entirely wanting, however.

Eastern red cedar in locations between the pine and southern Appalachian hard-wood belts shows a fair growth and promises well for management.

The bottom-land hard woods contain several species of almost phenomenal growth. Cottonwood here shows a greater growth than any other native American species, producing timber of saw size at thirty to forty years of age. Red gum and white and green ash also do remarkably well on the lowlands.

TABLE 3.—*Approximate average rate of growth for southern forests.*

Species.		Locality.	Forest type.	Age.											
				30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
Common name.	Botanical name.			Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Ash, white	Fraxinus americana	Arkansas	Bottom land	7.8	67	12.1	90	17.5	103	20.3	106				
Cedar, eastern red.	Juniperus virginiana	Alabama	"Forest grown"	5.0	35	9.0	50	14.0	59						
Cottonwood	Populus deltoides	Mississippi	Bottom land (sprout?).	21.7	126	30.4	143	38.4	152						
Cypress, bald	Taxodium distichum	Maryland	Swamp	3.9	31	7.8	53	15.2	82	20.5	95	35.0	107		
Gum, black	Nyssa sylvatica	No data.													
Gum, red	Liquidambar styraciflua.	South Carolina	Bottom land	11.2	87	16.8	106	23.4	116	26.9	120	34.2	125		
Pine, cuban	Pinus heterophylla	do	Lowland pine type	6.2	44	10.4	67	15.0	86	17.3	93	21.7	102	25.0	105
Pine, loblolly	Pinus tæda	do	Pine type	10.0	59	15.9	86	21.5	104	24.5	111	30.7	122		
Pine, longleaf	Pinus palustris	do	do	3.0	29	6.7	52	12.4	78	15.5	86	20.0	95	23.6	100
Pine, scrub	Pinus virginiana	Maryland	Pure stand—Dom	6.5	46	8.9	63								
Pine, shortleaf	Pinus echinata	Arkansas	Pine type	4.2	35	7.5	53	11.9	72	14.6	81	19.8	93	23.4	100

NOTE.—The diameter given is 4.5 feet from the ground.

ROCKY MOUNTAIN FORESTS.

The Rocky Mountain forests are entirely coniferous when the important species are considered.

Western yellow pine is the predominating species, and, excepting possibly Douglas fir, is the most rapid-growing species.

Lodgepole pine grows rather slowly, though it reproduces with a dense stand.

Engelmann spruce shows very slow growth in the study in Colorado.

No growth data have been collected on western larch, white fir, or silver pine—other important trees of the region.

The central fact in tree growth in this section is its slowness, which contrasts sharply with the rate of growth on the Pacific coast.

TABLE 4.—*Approximate average rate of growth for Rocky Mountain forests.*

Species.		Localty.	Forest type.	Age.											
Common name.	Botanical name.			30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
				Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Fir, alpine	Abies lasiocarpa	No data													
Fir, Douglas	Pseudotsuga taxifolia	Idaho	Fir slope—Quality I	1.6	8	5.9	35	12.3	63	15.6	72	21.1	86	24.9	93
Fir, white	Abies concolor	No data													
Larch, western	Larix occidentalis	do													
Pine, lodgepole	Pinus contorta	Montana	Lodgepole slope	4.0	40	6.6	60	9.6	70	11.2	73	14.0	76		
Pine, silver	Pinus monticola	No data													
Pine, western yellow	Pinus ponderosa	Arizona	Pure stand	4.3	18	8.1	30	12.0	43	14.0	48	18.7	61	21.6	68
Spruce, Engelmann	Picea engelmanni	Colorado	Dry slope			1.6		4.3		6.2		10.1	60	13.7	75

NOTE.—The diameter given is 4.5 feet from the ground.

PACIFIC COAST FORESTS.

The important species are here again all conifers, though with a growth greatly exceeding that of the Rocky Mountains. The Douglas fir produces an excellent growth and holds much promise for the future. Redwood in California equals or exceeds the fir in growth, with an added advantage of reproducing from stump sprouts. Western yellow pine ranks third in growth among the important species, though it is finally overtaken by sugar pine. Western hemlock holds fifth place.

No study of growth has been made on western red cedar or the less important spruce, firs, etc., except on the white fir in Siskiyou County in northern California, which reveals a rather slow growth in this locality. Western yellow pine and Douglas fir furnish a comparison between the Rocky Mountain and coast regions.

Eucalyptus globulus, or blue gum, introduced into southern California from Australia, grows at the rate of almost an inch in diameter and 5 feet or more in height per year from the seed, and sprouts exceed even this phenomenal growth. As a wood producer in favorable localities free from frost it has no equal.

TABLE 5.—*Approximate average rate of growth for Pacific coast forests.*

Species.		Locality.	Forest type.	Age.											
				30 years.		50 years.		80 years.		100 years.		150 years.		200 years.	
Common name.	Botanical name.			Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.	Diameter.	Height.
				Inches.	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*	*Inches.*	*Feet.*
Cedar, western red.	Thuya plicata	No data													
Fir, Douglas [a]	Pseudotsuga taxifolia	Washington	Fir-hemlock (virgin)	7.4	48	13.7	80	20.5	118	24.3	138	31.3	180	37.4	208
			Fir-hemlock (second growth).	10.5	68	14.6	114								
Fir, white	Abies concolor	California	Plateau, slope, and bottom.	0.7	8	3.9	24	9.0	57	12.2	76	19.5	111	26.0	136
Gum, blue [b]	Eucalyptus globulus	Southern California.	Plantations—Quality I—seedlings.	28.0	140										
Hemlock, western.	Tsuga heterophylla	Washington	Pure hemlock (virgin)	3.8	35	7.6	55	12.4	93	15.2	110	21.6	142	27.6	165
			Pure hemlock (second growth).	8.2	62	12.6	96	15.7	122	17.1	132				
Pine, sugar	Pinus lambertiana	California	Mixed slope (Sierras)	4.1	22	7.8	39	14.4	70	18.7	92	28.2	134	32.4	144
Pine, western yellow.	Pinus ponderosa	do	Mixed sugar pine	7.1	35	12.2	61	17.8	87	20.9	101	26.5	121	29.7	130
Redwood	Sequoia sempervirens	do	Moist flat-sprout	10.7	71	14.5	95								

[a] The diameter given is 4.5 feet from the ground, except for Douglas fir, which is for a stump height a little higher than 4.5 feet.

[b] An exotic introduced from Australia and widely planted for wind-break and fuel purposes in southern California.

From the preceding growth summary and the tables of the appendix the following table has been derived, estimating the time required to produce different wood crops. The periods of time are again averages often derived from growth in virgin forests and may be lowered slightly under the best second-growth conditions.

The average diameter at which timber may be best utilized for posts is assumed to be 6 inches, which means a range possibly of from 4 to 8 inches. Among the species commonly used in the East, chestnut (twenty years) is very rapid growing, but is equaled by catalpa in the Middle West farm plantations. White oak (thirty-five years) and eastern red cedar (thirty-five years) have a fair rate of growth. Northern white cedar, or arborvitæ (eighty years), grows exceedingly slowly. When the use of preservatives becomes more common, such species as red and black oaks (twenty-five years), loblolly, jack, red and white pines (twenty to thirty-two years), and yellow poplar (twenty years) may be used to good advantage, since they have rapid growth.

In the West data for cedar are wanting. Redwood (twenty years), however, will be a good producer. Assuming preservative treatment, yellow pine and Douglas fir (twenty-five years) promise well toward the coast, as does lodgepole pine (forty years) in the Rockies, for which the large number of trees per acre offset somewhat its slower growth.

TABLE 6.—*Time required to produce different wood crops.*

Species.	Locality.	Average diameter, 6 inches (posts).	Average diameter, 8 inches (handle, extract, pulp, spool, or fuel wood, props).	Average diameter, 11 inches (ties).	Average diameter, 14 inches (poles and piles).	Average diameter, 18 inches (saw timber).
Northern forests.						
		Years.	*Years.*	*Years.*	*Years.*	*Years.*
Arbor vitæ	Michigan	80	....	150	200	....
Aspen	Maine	....	40	....	....	....
Basswood	Michigan	....	50	....	....	130
Beech [a]	do	....	80	100	....	200
Birch, paper	Maine	....	50	....	....	....
Birch, yellow	New York	....	85	....	....	180
Fir, balsam [a]	do	....	100	....	....	....
Hemlock [a]	Michigan	....	100	130	....	....
Maple, sugar [a]	do	....	90	....	....	200
Pine, jack	Minnesota	30	45	....	....	....
Pine, red	Wisconsin	32	40	55	75	100
Pine, white	New York	32	40	55	....	90
Spruce, red	do	....	85	....	....	....
Tamarack	Minnesota	65	....	150	....	....
Central hardwood forests.						
Chestnut [b]	Maryland	20	25	40	55	85
Hickory (mockernut) [b]	Mississippi	50	65	....	....	135
Oak, black	Kentucky	25	35	50	....	130
Oak, red	do	25	30	45	....	100
Oak, white	do	35	45	80	....	160
Poplar, yellow	Tennessee, virgin forest.	....	45	....	....	110
Poplar, yellow [b]	Virginia, second growth.	20	25	....	....	....

[a] Species tolerant of shade which should show better results in second growth.

[b] Species growing under favorable conditions when measured.

TABLE 6.—*Time required to produce different wood crops*—Continued.

Species.	Locality.	Average diameter, 6 inches (posts).	Average diameter, 8 inches (handle, extract, pulp, spool, or fuel wood, props).	Average diameter, 11 inches (ties).	Average diameter, 14 inches (poles and piles).	Average diameter, 18 inches (saw timber).
Farm timber plantations.		*Years.*	*Years.*	*Years.*	*Years.*	*Years.*
Catalpa [a]	Illinois	20				
Larch, European [a]	do	23				
Maple, silver [a]	do		25			
Walnut, black [a]	do	25	35			
Cottonwood [a]	Nebraska		18			
Southern forests.						
Ash, white	Arkansas		30	45		85
Cedar, eastern red	Alabama	35	45	65		
Cottonwood	Mississippi		15			30
Cypress	Maryland	40		65	75	90
Gum, red	South Carolina			30		55
Pine, loblolly	do	20	25	40	55	70
Pine, longleaf	do			75	100	130
Pine, scrub	Maryland	30	40	70		
Pine, shortleaf	Arkansas		55	75	100	130
Rocky Mountain forests.						
Fir, Douglas	Idaho	50	60	75		125
Pine, lodgepole	Montana	45		100		
Pine, western yellow	Arizona	40	50	75		150
Spruce, Engelmann	Colorado	95		150		
Pacific coast forests.						
Fir, Douglas	Washington	25	35	45	50	75
Fir, white	California		75			140
Hemlock, western	Washington		50	70		125
Pine, sugar	California	40	50	65		100
Pine, western yellow	do	25	35	45	55	80
Redwood [b]	do	20	25	35	50	70

[a] Species growing under favorable conditions when measured.

[b] Species tolerant of shade which should show better results in second growth.

For handle and vehicle wood (6 to 10 inch trees) white and green ash in the southern valleys and bottoms promises well (thirty years). Hickory requires sixty-five years, though it may be used in smaller sizes at an earlier age. Hard or sugar maple in second growth should be ready earlier than the ninety years indicated by virgin forests. White oak from sprouts will reach 8 inches in about forty-five years.

For pulp wood (6 to 10 inch trees) red spruce will require about eighty-five years. Hemlock and balsam fir are still slower growing. Cottonwood in southern bottoms seems worth serious consideration as a future source of supply by planting, since studies thus far made show it will produce 6 to 10 inch pulp wood in fifteen years in those localities. Aspen in the North in forty years is a better grower than spruce, unless the fewer trees per acre will offset the better growth. Yellow poplar in the South (Virginia) in second growth often produces wood of pulp-wood size in twenty-five years, yielding in that period 23 to 35 cords per acre if the trees are closely spaced. If methods of utilizing the pines for pulp are improved, loblolly pine (twenty-five years) and jack and scrub pines (forty years) might receive some attention.

Chestnut extract wood may be produced in twenty-five years. Paper-birch spool wood in fifty years, for 6 to 10 inch wood.

For mine props red oak requires thirty years, black oak thirty-five years, and white oak forty-five years; red pine forty years, loblolly pine twenty-five years; western yellow pine in the Rocky Mountains fifty years; Douglas fir and western yellow pine on the west coast thirty-five years. For other species see Table 6.

Railroad ties of white cedar (arbor vitæ) require as much as one hundred and fifty years to produce them in the cedar swamps of the North. Tamarack requires a similar period. Eastern hemlock is also very slow growing in virgin forests, requiring one hundred and thirty years. Beech does a little better, with one hundred years. These species may be bettered somewhat in second growth, but can not approach chestnut, which in forty years will produce good ties; red oak in forty-five years; white oak will require eighty years, though in favorable localities from sprouts possibly a little less time will be required. Mixed oaks in sixty years will produce from 100 to 200 ties per acre. Red and white pine do very well in a fifty-five-year period, but loblolly pine will reach tie size in forty years and produce 160 to 400 ties per acre, according to the number of trees present at this time. Longleaf pine will require seventy-five years to produce a crop of ties; cypress sixty-five years. Red gum, if treated and properly handled, will make a good tie, and will produce a crop in thirty to thirty-five years in southern lowlands, where it is native.

Rocky Mountain species grow slowly, with little chance of tie production in less than an average of seventy-five years, except in very favorable localities. On the Pacific coast Douglas fir and western yellow pine will produce ties in forty-five years in favorable locations, and redwood sprouts in even less time.

For poles and piles chestnut leads in the East. Loblolly pine does excellently and red pine fairly in Minnesota. On the Pacific coast Douglas fir, western yellow pine, and redwood produce good-sized poles in fifty to fifty-five years. Judging from its growth in plantations in Illinois, European larch should produce poles in a short period. Eucalyptus globulus (blue gum) in southern California will produce material of this size in fifteen years and in even less time from sprouts in the best situations.

For saw timber an average diameter (always at 4.5 feet from the ground) of 18 inches is taken, and would mean a range of from 10 to 24 inches and a sprinkling of even larger trees. This is, of course, a smaller tree than the average of many species now cut. The future timber crops will, however, be largely composed of smaller trees, since it will not pay to wait for the large dimensions. Among the species producing timber of this average size in ninety years or less might be named white pine (ninety), chestnut (eighty-five), ash (eighty-five), cottonwood (thirty), cypress (ninety), red gum (fifty-five), loblolly pine (seventy), Douglas fir (seventy-five), western yellow pine (eighty), and redwood (seventy). Yellow poplar, red oak, sugar pine, and red pine will also, under good conditions, fall under this mark. The other species studied are slower growing.

ACRE YIELDS.

The production of a number of species in fully stocked (dense) natural second-growth stands may be seen from the following tables. Since the average second-growth forest of the country is clearly not as dense as it should be, and these figures show actual production only on occasional areas, the average production will fall far below these figures. The tables show rather the possibilities under forest management. Quality II locations are selected as representing an average rather than Quality I. To reduce the cubic-foot yield to cords, divide by 90, and to reduce to board feet, Scribner rule, multiply by 3 (for 10-inch trees) or 4 (for 16-inch trees). The actual saw cut should exceed this in straight sound trees.

TABLE 7.—*White pine*[a]*—Quality II—Southern New Hampshire.*

Age.	Trees per acre.	Mean diameter.	Mean height.	Acre yield.	
	Number.	*Inches.*	*Feet.*	*Cubic feet.*	*Board feet.*
40 years	870	6.8	52	5,800	....
50 years	510	9.0	66	7,300	20,000
60 years	380	10.7	76	8,500	25,000
70 years	310	11.9	84	9,150	30,000
80 years	260	12.9	89	10,300	35,000
90 years	220	14.5	93	11,000	41,000

[a] Data collected by L. Margolin.

White pine is seen to be one of the best timber-producing species in the forest, keeping up a high rate of increase to a considerable age. The larger number of trees per acre enable it to produce as well or better than the faster-growing loblolly pine, yellow poplar, and chestnut of the East.

TABLE 8.—*Loblolly pine in eastern Texas.*

Age.	Trees per acre.	Mean diameter.	Mean height.	Acre yield.	
	Number.	*Inches.*	*Feet.*	*Cubic feet.*	*Board feet.*[a]
20 years	405	6.1	45	2,600	6,500
30 years	185	9.5	65	3,200	7,450
40 years	150	12.4	85	3,700	9,300

[a] Herring rule.

This yield of second-growth loblolly pine (from Forest Service Bul. 64, by R. Zon) may be somewhat increased under careful management. The yield here quoted shows less than the preceding white-pine yield, due to the greater number of white pines per acre. Loblolly pine outstrips white pine in rate of growth for single trees, and in proper situations will receive strong support by southern foresters.

TABLE 9.—*Paper birch in Maine.*[a]

Age.	Mean diameter.	Mean height.	Acre yield.		
			Quantity.		6-inch diameter and over.
	Inches.	*Feet.*	*Cubic feet.*	*Cords.*	*Per cent.*
30 years	5.6	48	1,700	19	46
40 years	7.2	58	2,520	28	75
50 years	8.4	65	3,340	37	91
60 years	9.2	70	3,940	43	98
70 years	10.0	74	4,450	49	100

[a] Data collected by R. Marston.

The table for paper birch represents a woods classification of Quality I and may be a trifle high for average well-stocked, pure birch woods. The table will be of peculiar interest to spool makers. In applying it to large areas of natural forests a large deduction must be made for deficient stocking—again rather showing the possibilities of forest management.

TABLE 10.—*Second-growth yellow poplar—Quality II—Fairfax County, Va.*[a]

Age.	Trees per acre, 5 inches and over.	Mean diameter.	Mean height.	Acre yield.		
				Trees 5 inches and over.		Trees 7 inches and over (Scribner scale).
	Number.	*Inches.*	*Feet.*	*Cubic feet.*	*Cords.*	*Board ft.*
30 years	290	7.8	60	2,750	30	5,800
40 years	255	9.0	65	3,625	40	9,650
50 years	210	10.4	70	4,100	46	11,900
60 years	165	12.0	75	4,575	51	14,200

[a] Data collected by W. W. Ashe.

The mean diameter given above for dense stands is frequently exceeded in less crowded forests, though the acre yield shows the possibilities of the species under systematic management. This species should be of considerable value to southern pulp manufacturers.

TABLE 11.—*Mixed hard-wood coppice, Stewart and Decatur counties, Tenn.*

[White and black oaks about equal in quantity.]

Age.	Trees per acre.	Acre yield.[a]
	Number.	*Cubic feet.*
30 years	700	1,705
40 years	500	1,980
50 years	355	2,160
60 years	255	2,270
70 years	180	2,370

[a] Table prepared under direction of R. Zon.

The mixed hard woods of the southern Appalachians show a better uniform reproduction than the northern pines and spruce and far better than the southern pines, since reproduction results largely from sprouts, and one or two fires will not have the serious effect of preventing all reproduction, though fires do decrease the vitality of the forest and sometimes occur frequently enough to produce barren areas.

TABLE 12.—*Blue gum (Eucalyptus globulus)—Quality II—planted in southern California.*

Age.	Acre yield.			
	Seedlings.		Sprouts.	
	Cubic feet.	*Cords.*	*Cubic feet.*	*Cords.*
5 years	1,000	11	2,265	25
10 years	2,950	33	4,110	45
15 years	4,200	46	5,270	58
20 years	5,275	58	....	....
30 years	7,175	80	....	....

This species, imported from Australia, unfortunately can not be included among our important forest species, since it is confined to almost frostless regions. With its enormous and almost unheard of wood production it is playing an important role as wind-breaks and in the production of fuel in southern California, and may also furnish piles, implement wood, and other materials as it becomes better known. The yields quoted are exceeded by 50 per cent under most favorable conditions.

PRESENT AVERAGE PRODUCTION PER ACRE AND TOTAL PRODUCTION.

From the foregoing notes on the growth of the different species and the yield per acre in the infrequent fully stocked stands of second growth forest, little information can be gotten on the actual wood production throughout our forests, since growth conditions are often very unfavorable. In very old mature forests growth is offset by decay, and our millions of acres of this type of forest may for all practical purposes be regarded as nonproducing capital. Were all our forests of this class, the production per acre would be zero. Were all mature trees removed and the land all densely stocked with thrifty growth, the yield would approximate from 30 to 110 cubic feet per acre per year according to the species and locality. The actual forest represents all degrees of production between these two extremes. There are large bodies of overmature timber that are not increasing. There are small areas of pure second growth producing the maximum amount. There are culled-over areas containing mature defective trees or undesirable species mixed with second growth, areas denuded by ax and fire with no appreciable growth, and, the largest class of all, cut over and burned over lands with some growing trees, but usually not nearly as dense as the virgin forest.

To arrive at any approximation, then, of the total wood production of the country some rough classification of the entire forest area is necessary. Hence the following is offered:

TABLE 13.—*Classification of forest land.*

Region.	Total forest and woodland area.	Probably mature timber and woods.		Probably not restocking.		Probably growing forest and woodland.	
	Acres.	*Per cent.*	*Acres.*	*Per cent.*	*Acres.*	*Per cent.*	*Acres.*
Lake States	47,000,000	4	2,000,000	38	18,000,000	58	27,000,000
Northeastern States	48,000,000	4	2,000,000	18	8,000,000	78	38,000,000
Central States	71,000,000	9	6,000,000	15	11,000,000	76	54,000,000
Southern States:							
Pine land (60 per cent)	124,000,000	33	41,000,000	27	33,000,000	40	50,000,000
Hard wood land (40 per cent)	82,000,000	43	35,000,000	7	6,000,000	50	41,000,000
Rocky Mountain States	97,000,000	70	68,000,000	12	12,000,000	18	17,000,000
Pacific Coast States	76,000,000	80	61,000,000	3	2,000,000	17	13,000,000
Total	545,000,000	....	215,000,000	....	90,000,000	....	240,000,000

The Lake States include Minnesota, Wisconsin, and Michigan; the Northeastern States include Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania; the Central States include West Virginia, Ohio, Indiana, Illinois, Kentucky, Tennessee, Iowa, North Dakota, South Dakota, Nebraska, Kansas, and Missouri; the Southern States include Maryland, Delaware, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Texas, and Oklahoma; the Rocky Mountain States include Montana, Idaho, Utah, Wyoming, Colorado, Nevada, Arizona, and New Mexico; the Pacific Coast States include Washington, Oregon, and California.

The total forest area, including woodland, is seen to amount to approximately 545,000,000 acres, of which about 50,000,000 acres are scrubby woodland, producing only cord wood. This is confined largely to the Southwest, such as the scrub oak, piñon, and juniper lands of California, New Mexico, Arizona, Texas, and other Rocky Mountain States. This estimate of total forest area is based on almost complete returns from county clerks, usually supporting estimates previously made by the United States Geological Survey for Washington and Oregon, the Forest Service forest maps of California and New Hampshire, and the more general state estimates of Doctor Fernow.

The classification into mature timber and cut and burned land probably not restocking are estimates based on reports of Professor Roth for Michigan and Wisconsin and General Andrews for Minnesota, the Geological Survey revised township estimate for Washington and Oregon, by Henry Gannett, together with special reports of state foresters, and more general regional reports, such as the "Report of the Secretary of Agriculture on the White Mountains and Southern Appalachian Watersheds, 1908;" "Southern Appalachian Forests," Ayers and Ashe, Geological Survey; "Timber Pines of the Southern United States," Forest Service Bulletin 13, by Roth, etc. That some difference of opinion may be expressed on this classification is not to be doubted, but the totals are good, errors in high and low estimates compensating to some degree.

The mature timber totals over 188,000,000 acres, which might be raised to approximately 215,000,000 if all woodland such as the scub oak, juniper, and piñon lands of the Southwest is included. It is evident that there is little mature timber in the Lake and Northeastern States. The States included as Central States have a little more mature timber, though culled forests, which consist largely of mature trees, are here included under growing forests to be conservative. The Southern States are figured as having one-third mature timber on pine lands and a little larger proportion of the hard woods of the alluvial bottoms and southern Appalachians. The Rocky Mountain and Pacific coast forests are largely mature forests. Since there has been a great lumber output on the coast it might be supposed that the Rocky Mountain region should have a larger percentage of mature forest, but the thinner forest of the Rockies and much greater damage from fire have tended to lessen the mature forest percentage and greatly increase the "not restocking" percentage. This large area of mature forest can not be considered as increasing materially by growth above the loss by decay, windfalls, insects, etc. The burned areas restocking are included under growing forest.

Under the head of "Probably not restocking" the Lake States lead with 38 per cent. This is due perhaps to the more complete reports and forest and logging conditions which invited the many great conflagrations credited to this region. The larger amount of hard wood, different topography, denser population, larger percentage in small wood lots, and other factors decrease the percentage of forest not restocking for the Northeastern States. These same factors—notably the composition of the forest as of hard woods almost entirely with sprout reproduction—lessen it still more for the Central States. In the Southern States on the pine lands it rises sharply and would be still higher were not the effects of fires less destructive in the more open mature forests still existing. Southern hard woods suffer much less. This is due to their location in the lowlands and mountains, to the less inflammability of nonresinous wood, and to sprout reproduction. In proportion to the cut-over land the Rocky Mountains show a large percentage of land not restocking, while the Pacific coast climatic conditions make reseeding better and safer. The areas of land not restocking are believed to be very conservative even though the total seems startling when placed at about 82,000,000 acres of forest land or 90,000,000 acres of forest and woodland. To the observant forester several trips through the Lake State pineries and southern pineries (where one-half of this land is to be found) are sufficiently convincing. This is the second large item which must be withdrawn from the total so-called forest area. The question may be raised whether this has not already been excluded in the classification of total forest and woodland. It is not, because it is inseparably mingled with the mature and growing timber areas, and it is still potential forest land but unable to restock on account of recurring fires and lack of seed trees. For example, Minnesota is given 15,000,000 acres of forest land, only 7,500,000 of which is restocking to a degree indicative of a second crop. The other 7,500,000, while not entirely devoid of tree growth, will require many decades of efficient fire protection and a large amount of artificial regeneration to bring it into the producing forest class.

The growing forest area is gotten by deducting the mature forest and the area not restocking from the total forest area. This is approximately 225,000,000 acres of forest land, or 240,000,000 acres of forest and woodland. These figures give a total forest area of about 495,000,000 acres, which is raised to 545,000,000 to include woodlands (lands incapable of producing saw timber forest).

Having thus analyzed the total forest area and secured an approximation for the area of growing or producing forest, there remains a discussion of the actual increment on this area. Since (as has been stated before) the growing forest is made up of all conditions of growth from the lightly culled mature forests producing little increment to the pure dense stands of young growth with an increment approaching the maximum, the arriving at an average production is very difficult. The most important single factor is the amount of growing stock present or the density. The second is the age of the growing stock.

In the first column of the table below, the annual production per acre of fully stocked forest is taken as the basis for calculation (being the average for the life of the trees to maturity for all qualities of forest). This is expressed in cubic feet of stem volume (not all of which is merchantable) gotten from the few American yield tables (see Appendix) supplemented by German yield tables, and weighted roughly according to the species in the growing forests of each region.

TABLE 14.—*Estimated growth per acre.*

Region.	Average estimated production in fully stocked forest per acre per year.	Average "best virgin forest" density in per cent of fully stocked.	Estimated density of immature forest compared with best virgin.	Probable growth per acre in growing forest.
	Cubic feet.	*Per cent.*	*Per cent.*	*Cubic feet.*
Lake States	90	60	70	38
Northeastern States	80	60	70	33
Central States	60	70	60	25
Southern States:				
Pine land	70	46	65	21
Hard-wood land	70	70	60	29
Rocky Mountain States	30	58	60	9
Pacific coast States	110	73	70	56

In order to see how the density of our virgin forests compares with the fully stocked forests of the yield tables recourse is taken to a comparison of basal areas (area of tree cross sections). The total basal area (see Appendix) for northern virgin forests containing a large percentage of conifers ranges from 75 to 200 square feet, averaging about 120; the central hard-wood forests from 90 to 150, averaging about 117 square feet; the southern pine forests 30 to 120, averaging 70 square feet; the Rocky Mountain forests 30 to 130, averaging 80 square feet; and the Pacific coast forests 190 to 240, averaging 220 square feet. These basal areas, when compared with Quality II 80-year white pine in New England (see Appendix for normal yield table basal areas and increments), with 242 square feet per acre; paper birch, Quality I, 60 years, in New England, with 120 square feet; loblolly pine in Texas, at 40 years, with 126 square feet; second-growth hard woods in the Southern Appalachians, with 140 square feet; Norway spruce 120 years old, in Germany, with 288 square feet; beech with 192 square feet; and Scotch pine with 212 square feet, show that our virgin forests, even of the best grades as selected and of much greater age than the normal forests compared, are not nearly normally stocked—the redwoods of California being exceptional. This deficiency of stocking in the best virgin forest is expressed by a percentage in column 2 of the above table. Column 3 gives the estimated relation between the immature or growing forest and the best virgin tracts. Here the percentage for the central and southern hard woods is placed at 60, in order to allow for the large number of mature trees still in these culled forests. The density, including these mature nonproducing trees, would of course be much higher than 60 per cent of the virgin forest density.

By multiplying the production in the fully stocked forest (Table 14) by the percentages of effective stocking in virgin and growing forests successively, the last column of that table is secured, indicating a production of from 21 to 56 cubic feet per acre per year in the immature forest in all regions except the Rocky Mountain region, where the large area of juniper, piñon, and scrub oak woodland included in the total wooded area reduces an already low average growth to approximately 9 cubic feet. These figures are believed to be, if anything, higher than the truth.

Applying this estimated average growth to the area of growing forest—

TABLE 15.

Region.	Probable area of growing forest and woodland.	Estimated growth per acre.	Estimated total production.
	Acres.	*Cubic feet.*	*Cubic feet.*
Lake States	27,000,000	38	1,026,000,000
Northeastern States	38,000,000	33	1,254,000,000
Central States	54,000,000	25	1,350,000,000
Southern States:			
Pine land	50,000,000	21	1,050,000,000
Hard-wood land	41,000,000	29	1,189,000,000
Rocky Mountain States	17,000,000	9	153,000,000
Pacific coast States	13,000,000	56	728,000,000
Total	240,000,000	[a]28	6,750,000,000

[a] Average.

an estimated total production of about 6,700,000,000 cubic feet is indicated. This is an average of about 28 cubic feet per acre for the estimated 240,000,000 acres of growing forest and woodland, or about 12 cubic feet for the entire forest and woodland area of 545,000,000 acres, including mature and devastated forests.

Of this probable total of 6,700,000,000 cubic feet the part suitable for saw timber would represent an actual mill output of probably much less than 20,000,000,000 board feet, the rest being cord wood and mill waste.

APPENDIX.

Arbor vitæ.

Age.	Diameter growth.		Height growth.	
	St. Louis County, Minn.[a]			
	Diameter breast-high	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	0.3	Decade measurements on 44 1-foot stumps 70 to 150 years old.	6	Age diameter and diameter-height curves.
20 years	0.7		8	
30 years	1.2		11	
40 years	1.6		13	
50 years	2.1		15	
60 years	2.8		18	
70 years	3.5		22	
80 years	4.2		25	
90 years	5.3		29	
100 years	6.2		32	
110 years	7.0		34	
120 years	7.5		36	
130 years	8.0		38	
140 years	8.3		39	
150 years	8.8		40	
160 years	9.4		40	
170 years	10.1			

[a] White Pine Study, by C. S. Chapman, 1903.

Ash, green.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	2.1	5-year measurements on 57 5-foot stumps 14 to 44 years old.	19	7-foot section measurements on 57 trees 14 to 44 years old.
20 years	3.6		28	
30 years	5.0		36	
40 years	5.4		40	
50 years	5.6		43	

[a] Plantations, L. C. Miller, 1904.

Ash, white.

Age.	Diameter growth.	
	Dutchess County, N. Y.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years	1.6	5-year measurements on 15 4.5-foot stumps 7 to 44 years old.
20 years	3.2	
30 years	4.2	
40 years	4.8	

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.

Ash, white and green.

Age.	Diameter growth.			
	Richland County, S. C.[a]		Mississippi County, Ark.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	2.7	Decade measurements on 410 2-foot stumps 32 to 180 years old.	2.6	Decade measurements on 331 3-foot stumps 39 to 162 years old.
20 years	5.2		5.4	
30 years	7.3		7.8	
40 years	9.3		10.0	
50 years	11.2		12.1	
60 years	13.1		14.0	
70 years	14.8		15.8	
80 years	16.6		17.5	
90 years	18.3		19.0	
100 years	19.8		20.3	
110 years	21.5		....	
120 years	23.0		....	
130 years	24.6		....	
140 years	26.1		....	
150 years	27.7		....	

[a] Ash Study, by K. W. Woodward, 1905.

[b] Ash Study, by G. M. Homans, 1905.

Aspen.

Age.	Diameter growth.				Height growth.	
	(With jack pine) Hubbard County, Minn.[a]		Franklin and Somerset counties, Me.[b]		Franklin and Somerset counties, Me.	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*	
10 years	1.1	Breast-high decade measurements on 6 trees 39 to 84 years old.	1.5	5-year measurements on 409 4.5-foot stumps 5 to 89 years old.	15	2639 sectional ring counts.
20 years	2.7		3.7		32	
30 years	4.0		6.0		45	
40 years	5.4		7.9		56	
50 years	6.8		9.4		65	
60 years	....		10.6		71	
70 years	....		11.5		74	
80 years	....		12.0		75	
90 years	....		12.5		77	
100 years	....		12.8		78	
110 years	....		....		79	
120 years	....		....		80	

[a] Red Pine Study, by H. H. Chapman, 1905. [b] Aspen Study, by R. L. Marston, 1903.

Basswood.

Age.	Diameter growth.	
	Leelanau County, Mich.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years	1.4	Decade measurements on 73 2.1 to 3.0 foot stumps 63 to 180 years old.
20 years	2.9	
30 years	4.5	
40 years	6.3	
50 years	8.1	
60 years	9.9	
70 years	11.6	
80 years	13.2	
90 years	14.5	
100 years	15.7	
110 years	16.6	
120 years	17.5	
130 years	18.1	
140 years	18.6	
150 years	19.1	
160 years	19.4	
170 years	19.8	
180 years	20.0	
190 years	20.2	
200 years	20.4	

[a] Newhall Working Plan, by S. J. Record, 1905.

Beech.

Age.	Diameter growth.			
	Leelanau County, Mich.[a]		Franklin County, N.Y.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	0.2	Decade measurements at 2.0 to 2.9 feet on 61 trees 69 to 202 years old.	0.6	189 trees with stumps of various heights and diameters.
20 years	1.0		1.0	
30 years	1.8		1.5	
40 years	2.7		2.0	
50 years	3.8		2.5	
60 years	5.3		3.2	
70 years	6.7		3.8	
80 years	8.0		4.6	
90 years	9.2		5.5	
100 years	10.2		6.4	
110 years	11.0		7.4	
120 years	11.7		8.5	
130 years	12.3		9.5	
140 years	13.0		10.6	
150 years	13.6		11.6	
160 years	14.3		12.6	
170 years	14.8		13.6	
180 years	15.4		14.6	
190 years	16.0		15.6	
200 years	16.6		16.5	
210 years	....		17.5	
220 years	....		18.5	
230 years	....		19.5	
240 years	....		20.5	
250 years	....		21.5	
260 years	....		22.5	
270 years	....		23.4	
280 years	....		24.3	
290 years	....		25.0	
300 years	....		25.7	

[a] Newhall Working Plan, by S. J. Record, 1905.
[b] Working Plan for St. Regis Tract, by O. W. Price, 1899.

Birch, paper.

Age.	Diameter growth.				Height growth.			
	Seedling.[a]		Sprout.[b]		Seedling.		Sprout.	
	Piscataquis County, Me.[c]		Carroll County, N. H.[c]		Piscataquis County, Me.[c]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	1.1	Decade measurements on 50 1 to 2 foot stumps 62 to 88 years old.	1.8	Decade measurements on 30 1 to 2 foot stumps 43 to 61 years old.	13	Sectional age counts on 50 trees.	19	Sectional age counts on 30 trees.
20 years	3.4		4.0		30		36	
30 years	5.3		6.9		44		49	
40 years	6.8		7.9		54		60	
50 years	8.0		8.8		62		70	
60 years	8.9		....		68		78	
70 years	9.7		....		74		....	
80 years	10.2		....		78		....	
90 years	....		....		81		....	

[a] Low, rocky ground near a pond.
[b] Very rocky thin-soiled hillside.
[c] Paper Birch Study, by S. T. Dana, 1907.

Birch, yellow.

Age.	Diameter growth.			
	Leelanau County, Mich.[a]		Franklin County, N. Y.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	0.9	Decade measurements on 20 2 to 2.9 foot stumps 75 to 187 years old.	1.1	332 trees with stumps of various heights and diameters.
20 years	2.3		1.8	
30 years	3.8		2.6	
40 years	5.3		3.5	
50 years	6.8		4.5	
60 years	8.4		5.4	
70 years	10.0		6.4	
80 years	11.5		7.4	
90 years	12.9		8.4	
100 years	14.2		9.4	
110 years	15.4		10.4	
120 years	16.6		11.4	
130 years	17.7		12.4	
140 years	18.9		13.4	
150 years	20.0		14.4	
160 years	21.1		15.5	
170 years	22.2		16.5	
180 years	23.3		17.5	
190 years	24.4		18.5	
200 years	25.5		19.4	
210 years			20.2	
220 years			21.1	
230 years			21.9	
240 years			22.7	
250 years			23.4	
260 years			24.1	
270 years			24.7	
280 years			25.3	
290 years			25.9	
300 years			26.4	

[a] Newhall Working Plan, by S. J. Record, 1905.
[b] Working Plan for St. Regis Tract, by O. W. Price, 1899.

Catalpa.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	2.8	5-year measurements on 24 5-foot stumps 15 to 25 years old.	19	7-foot sections on 24 trees 15 to 25 years old.
20 years	4.9		27	
30 years	6.4		33	

[a] Plantations, L. C. Miller, 1904.

Cedar, red.

Age.	Diameter growth.							
	Open grown.		Forest grown.[a]					
	Marengo and Perry counties, Ala.[b][c]						Dutchess County, N. Y.[d][e]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.0	Decade measurements on 46 0.5 to 1 foot stumps 51 to 95 years old.	0.4	Decade measurements on 296 0.5 to 1 foot stumps 56 to 92 years old.	0.2	Decade measurements on 68 0.5 to 1 foot stumps 68 to 84 years old.	0.7	5-year measurements on 28 0.5-foot stumps 34 to 67 years old.
20 years	3.9		2.7		1.3		1.9	
30 years	6.9		5.0		2.7		2.8	
40 years	9.3		7.1		4.4		3.6	
50 years	11.2		9.0		6.5		4.2	
60 years	12.8		10.7		8.9		4.8	
70 years	14.3		12.3		11.4		......	
80 years	15.6		14.0		13.9		......	
90 years	......		15.7		......		......	

Age.	Height growth.			
	Forest grown.		Open grown.	
	Marengo and Perry counties, Ala.[b][c]			
	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*	
10 years	4.3	Section measurements on 161 trees.	6.6	Section measurements on 60 trees.
20 years	13.0		19.6	
30 years	23.2		21.1	
40 years	33.4		......	
50 years	......		......	
60 years	......		......	
70 years	......		......	
80 years	......		......	
90 years	......		......	

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[a] Suppressed for about twenty years.

[b] About 50 per cent cedar; rest hard woods. Moderately deep soil. Situation varies from coves to flat uplands.

[c] Red Cedar Study, by L. L. White, 1906.

[d] Rogers and Huyler Working Plan, by J. G. Peters, 1905.

[e] Old field type. Agricultural soil.

Chestnut.

Age.	Diameter growth.							
	Slope.							
	Dutchess County, N. Y.[a] [b]		Nicholas County, W. Va.[c]		Johnson County, Tenn.[c]		Polk and Monroe counties, Tenn.[c]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	2.5	Decade measurements on 33 1.5-foot stumps 29 to 70 years old.	0.5	Decade measurements on 60 2.5-foot stumps 54 to 200 years old.	0.4	Decade measurements on 52 2.5-foot stumps 56 to 194 years old.	0.5	Decade measurements on 67 2.5-foot stumps 24 to 200 years old.
20 years	4.9		2.4		2.5		3.0	
30 years	7.2		4.3		4.8		5.3	
40 years	9.4		6.4		7.2		7.3	
50 years	11.4		8.4		9.4		9.4	
60 years	12.9		10.4		11.4		11.4	
70 years	....		12.5		13.1		13.4	
80 years	....		14.4		14.5		15.3	
90 years	....		16.3		?15.7		17.2	
100 years	....		18.2		?16.9		18.9	
110 years	....		19.9		?17.8		20.3	
120 years	....		21.6		?18.7		21.6	
130 years	....		23.2		?19.6		22.8	
140 years	....		24.9		?20.4		23.9	
150 years	....		26.6		?21.2		24.7	
160 years	....		28.4		?22.0		25.5	
170 years	....		30.2		?22.7		26.3	
180 years	....		31.9		?23.4		27.0	
190 years	....		33.3		?24.2		27.7	
200 years	....		....		?24.9		28.4	

Age.	Diameter growth.							
	Cove.		Second growth.		Seedlings.		Coppice.	
	Polk and Monroe counties, Tenn.[c]		Lyon County, W. Va.[d]		Prince George, Charles, Calvert, and Anne Arundel counties, Md.[e] [f]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	0.7	Decade measurements on 66 0.5 to 4.5 foot stumps 21 to 176 years old.	1.6	Decade measurements on 47 4.5-foot stumps 14 to 65 years old.	0.8	490 trees.	3.8	3,823 trees.
20 years	3.1		3.7		3.4		6.8	
30 years	5.6		5.4		6.0		9.3	
40 years	8.2		6.9		8.7		11.4	
50 years	11.1		8.3		11.2		13.4	
60 years	13.7		9.6		13.4		15.1	
70 years	16.0		11.0		15.4		16.7	
80 years	18.4		....		17.2		18.0	
90 years	20.3		....		18.8		19.2	
100 years	21.7		....		20.1		19.8	
110 years	?22.7		....		21.0		20.4	
120 years	?23.5		....		21.6		20.8	
130 years	?24.1		....		....		....	
140 years	?24.5		....		....		....	
150 years	?24.9		....		....		....	
160 years	?25.1		....		....		....	
170 years	?25.3		....		....		....	
180 years	?25.5		....		....		....	
190 years	....		....		....		....	
200 years	....		....		....		....	

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.
[b] On white oak type.
[c] Commercial Tree Study, Walter Mulford, 1905-6.
[d] United States Coal and Oil Lands, R. C. Hawley, 1904.
[e] Chestnut Study, by R. Zon, 1902.
[f] In mixture with scrub pine and hard woods on gentle slopes.

Chestnut—Continued.

Age.	Height growth.			
	Seedlings.		Coppice.	
	Prince George, Charles, Calvert, and Anne Arundel counties, Md.[a] [b]			
	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*	
10 years	7	181 trees.	23	1,071 trees.
20 years	17		42	
30 years	33		57	
40 years	52		69	
50 years	64		77	
60 years	73		83	
70 years	80		87	
80 years	84		90	
90 years	88		92	
100 years	91		93	
110 years	93		94	
120 years	95		95	
130 years	....		....	
140 years	....		....	
150 years	....		....	
160 years	....		....	
170 years	....		....	
180 years	....		....	
190 years	....		....	
200 years	....		....	

[a] Chestnut Study, by R. Zon, 1902.
[b] In mixture with scrub pine and hard woods on gentle slopes.

Cottonwood.

Age.	Diameter growth.						Height growth.	
	Bolivar County, Miss.[a]		Richland County, S. C.[a]		Eastern Nebraska.[b]		Eastern Nebraska.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Inches.*		*Feet.*	
10 years	8.1	Decade measurements on 335 3-foot stumps 12 to 106 years old.	6.2	Decade measurements on 396 3-foot stumps 14 to 131 years old.	5.1	4-year measurements on 50 1-foot stumps 9 to 46 years old.	33	7-foot sections on 50 trees 9 to 46 years old.
20 years	15.8		12.6		9.4		55	
30 years	21.7		17.4		12.2		65	
40 years	26.6		21.4		13.3		69	
50 years	30.4		25.1		13.8		73	
60 years	33.4		28.2		....		....	
70 years	36.0		30.9		....		....	
80 years	38.4		33.5		....		....	
90 years	40.8		35.7		....		....	
100 years	....		37.6		....		....	
110 years	....		39.3		....		....	
120 years	....		40.7		....		....	

[a] Cottonwood Study, by G. M. Homans and K. W. Woodward, 1905.
[b] Plantations, L. C. Miller, 1904.

Fir, alpine.

Age.	Height growth. Gunnison County, Colo.[a]	Age.	Height growth. Gunnison County, Colo.[a]
	Feet.		*Feet.*
10 years	2.0	50 years	6.7
20 years	3.7	60 years	7.3
30 years	5.1	70 years	7.8
40 years	6.1		

[a] Planting Reconnaissance, S. B. Detweiler, 1905.

Fir, balsam.

Age.	Diameter growth.							
	Hardwood slope.		Dry swamp.		Wet swamp.		Somerset County, Me.[a]	
	Franklin County, N. Y.[a]							
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	0.2	Decade measurements on 613 trees with varying stumps 17 to 147 years old.	0.2	Decade measurements on 448 trees with varying stumps 25 to 149 years old.	....	Decade measurements on 372 trees with varying stumps 18 to 150 years old.	....	Decade measurements on 135 4.5-foot stumps 18 to 109 years old.
20 years	1.2		1.2		0.7		1.1	
30 years	2.5		2.3		1.7		2.0	
40 years	4.0		3.7		2.7		2.9	
50 years	5.2		5.2		3.9		3.7	
60 years	6.2		6.2		4.9		4.4	
70 years	7.0		6.9		5.7		5.0	
80 years	7.5		7.2		6.2		5.4	
90 years	8.0		7.5		6.6		5.8	
100 years	8.4		7.6		7.0		6.0	
110 years	8.7		7.8		7.3		6.2	
120 years	9.0		7.9		7.5		6.6	
130 years	9.3		8.1		7.7		....	
140 years	9.6		8.2		7.9		....	
150 years	9.8		8.3		8.0		....	

Age.	Diameter growth.		Height growth.	
	St. Louis County, Minn.[b]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	....	Decade measurements on 68 4.5-foot stumps 41 to 128 years old.	2.5	298 trees.
20 years	....		4.4	
30 years	1.0		5.0	
40 years	2.2		5.6	
50 years	3.5		6.6	
60 years	4.7		....	
70 years	5.8		....	
80 years	6.9		....	
90 years	8.0		....	
100 years	8.8		....	
110 years	9.4		....	
120 years	9.8		....	
130 years	10.1		....	
140 years	....		....	
150 years	....		....	

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[a] Balsam Fir Study, by R. Zon, 1903–4.
[b] White Pine Study, by C. S. Chapman, 1903.

Fir, white.

Age.	Diameter growth.							
	Bottom.		Plateau.		Slope.		All types.	
	Siskiyou County, Cal.[a]							
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	....	Decade measurements on 279 4.5-foot stumps 27 to 200 years old.	....	Decade measurements on 214 4.5-foot stumps 42 to 198 years old.	....	Decade measurements on 383 4.5-foot stumps 45 to 200 years old.	....	Decade measurements on 876 4.5-foot stumps 30 to 285 years old.
20 years	....		....		....		....	
30 years	1.2		....		....		0.7	
40 years	2.4		1.7		1.6		2.3	
50 years	3.6		3.3		3.1		3.9	
60 years	5.0		5.1		4.8		5.7	
70 years	6.4		7.3		6.5		7.4	
80 years	7.9		9.7		8.1		9.0	
90 years	9.3		12.3		9.5		10.7	
100 years	11.0		14.7		10.7		12.2	
110 years	12.4		17.3		11.9		13.6	
120 years	13.8		19.9		12.9		15.2	
130 years	15.0		22.3		13.9		16.7	
140 years	16.2		24.7		14.9		18.1	
150 years	17.3		26.8		15.9		19.5	
160 years	18.3		28.6		16.9		20.9	
170 years	19.3		30.2		17.9		22.2	
180 years	20.3		31.6		18.8		23.5	
190 years	21.3		....		19.8		24.8	
200 years	22.2		....		20.7		26.0	

Age.	Height growth.							
	Bottom.		Slope.		Plateau.		All types.	
	Siskiyou County, Cal.[a]							
	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*		*Feet.*		*Feet.*	
10 years	....	Combined age and height curves.	....	Combined age and height curves.	....	Combined age and height curves.	....	Combined growth diameter and height curves.
20 years	....		....		....		....	
30 years	10		....		....		8	
40 years	16		13		12		16	
50 years	23		22		20		24	
60 years	30		33		30		36	
70 years	38		44		44		46	
80 years	47		55		56		57	
90 years	56		63		69		67	
100 years	67		71		79		76	
110 years	75		78		90		83	
120 years	83		83		101		91	
130 years	90		88		112		99	
140 years	96		93		122		105	
150 years	104		97		131		111	
160 years	107		101		138		117	
170 years	112		106		143		122	
180 years	117		110		147		127	
190 years	121		114		....		132	
200 years	125		118		....	....	136	

[a] White Fir Study, by P. D. Kelleter, 1905.

Gum, red.

Age.	Diameter growth.			
	New Madrid County, Mo.[a]		Richland County, S. C.[a]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	1.6	Decade measurements on 656 stumps of various heights and diameters.	3.8	Decade measurements on 796 stumps of various heights and diameters.
20 years	3.8		7.8	
30 years	6.3		11.2	
40 years	9.2		14.2	
50 years	12.2		16.8	
60 years	15.1		19.2	
70 years	18.0		21.4	
80 years	20.9		23.4	
90 years	23.5		25.3	
100 years	25.8		26.9	
110 years	27.7		28.4	
120 years	29.3		29.9	
130 years	30.7		31.3	
140 years	31.8		32.7	
150 years	32.8		34.2	
160 years	33.6		35.6	
170 years	34.3		37.1	
180 years	34.9		38.6	
190 years	35.4		40.0	
200 years	35.9		....	
210 years	36.3		....	
220 years	36.6		....	
230 years	37.0		....	
240 years	37.3		....	
250 years	37.6		....	
260 years	37.8		....	
270 years	38.1		....	
280 years	38.4		....	
290 years	38.6		....	
300 years	38.9		....	

[a] Red Gum Study, by A. K. Chittenden, 1903-4.

Hemlock.[a]

Age.	Diameter growth.					
	Johnson County, Tenn.[a]		Mitchell County, N. C.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*	
20 years	0.2	Decade measurements on 131 2.5-foot stumps 111 to 200 years old.	0.3	Decade measurements on 124 2-foot stumps 100 to 200 years old.	....	Decade measurements on 308 3-foot stumps 89 to 200 years old.
30 years	.9		1.0		1.1	
40 years	1.9		1.8		2.2	
50 years	3.0		2.8		3.4	
60 years	4.1		3.8		4.7	
70 years	5.3		4.9		6.2	
80 years	6.7		6.2		7.6	
90 years	8.0		7.3		9.1	
100 years	9.4		8.6		10.5	
110 years	10.7		9.7		11.9	
120 years	11.8		11.0		13.2	
130 years	12.9		12.2		14.5	
140 years	14.0		13.5		15.5	
150 years	15.1		14.6		16.5	
160 years	16.1		15.7		17.4	
170 years	17.1		16.5		18.3	
180 years	18.1		17.4		19.2	
190 years	19.1		18.2		20.0	
200 years	20.0		19.0		20.7	
210 years	....		....		....	
220 years	....		....		....	
230 years	....		....		....	
240 years	....		....		....	
250 years	....		....		....	
260 years	....		....		....	
270 years	....		....		....	
280 years	....		....		....	
290 years	....		....		....	
300 years	....		....		....	

Age.	Diameter growth.			
	Greenbrier County, W. Va.[a]		Leelanau County, Mich.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	....	Decade measurements on 47 2.5-foot stumps 137 to 200 years old.	0.1	Decade measurements on 186 2 to 2.9 foot stumps 109 to 325 years old.
20 years	0.4		.7	
30 years	0.9		1.3	
40 years	1.3		2.1	
50 years	1.9		2.9	
60 years	2.4		3.8	
70 years	2.9		4.7	
80 years	3.6		5.7	
90 years	4.2		6.7	
100 years	4.9		7.8	
110 years	5.6		9.0	
120 years	6.4		10.0	
130 years	7.3		11.2	
140 years	8.1		12.3	
150 years	8.9		13.4	
160 years	9.9		14.5	
170 years	10.9		15.5	
180 years	11.9		16.5	
190 years	12.7		17.5	
200 years	13.5		18.4	
210 years	....		19.3	
220 years	....		20.1	
230 years	....		20.9	
240 years	....		21.6	
250 years	....		22.2	
260 years	....		22.8	
270 years	....		23.3	
280 years	....		23.8	
290 years	....		24.3	
300 years	....		24.7	

[a] Commercial Tree Study, by Walter Mulford, 1905-6.
[b] Newhall Working Plan, by S. J. Record, 1905.

Hickories.

Age	Diameter growth.	
	Dutchess County, N. Y.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years	1.7	5-year measurements on 12 4.5-foot stumps 28 to 62 years old.
20 years	3.6	
30 years	5.4	
40 years	7.1	
50 years	8.6	
60 years	10.0	

Age.	Diameter growth.			Age.	Diameter growth.		
	Ohio Valley.[b]				Ohio Valley.[b]		
	Mockernut.	Pignut.	Shagbark.		Mockernut.	Pignut.	Shagbark.
	Diameter breast-high.				Diameter breast-high.		
	Inches.	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*
10 years	0.9	0.6	0.6	70 years	10.9	8.6	7.8
20 years	2.6	1.8	1.7	80 years	12.5	10.0	9.0
30 years	4.3	3.1	2.9	90 years	14.1	11.4	10.3
40 years	6.0	4.4	4.1	100 years	15.7	12.9	11.6
50 years	7.7	5.7	5.3	110 years	17.3	13.3	12.9
60 years	9.3	7.2	6.5	120 years	18.9	15.7	14.2

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.
[b] Hickory Study, A. T. Boisen, 1907.

Juniper, Rocky Mountain.

Age.	Diameter growth.				Height growth.	
	Partially shaded.		Open grown.		Partially shaded.	Open grown.
	Randall County, Tex.[a]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Height.
	Inches.		*Inches.*		*Feet.*	*Feet.*
10 years		Stumps 1 foot high.		Stumps 1 foot high.		
20 years						
30 years						
40 years						
50 years						
60 years	5.5		8.5		31	34
70 years	6.4		9.8		33	36
80 years	7.2		11.1		35	33
90 years	8.0		12.1		37	41
100 years	8.8		12.9		38	43
110 years	9.5		13.6		40	45
120 years	10.1		14.2		41	47
130 years	10.7		14.6		42	49
140 years	11.2		15.0		43	50
150 years	11.7				44	
160 years	12.2				45	
170 years	12.7				47	
180 years	13.2				49	
190 years	13.7				50	
200 years	14.2				52	

[a] Palodura Tract, H. H. Chapman, 1904.

Locust, honey.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	3.6	5-year measurements on 5-foot stumps 17 to 35 years old.	18	7-foot sections on 12 trees 17 to 30 years old.
20 years	5.3		27	
30 years	6.7		35	
40 years	....		43	

[a] Plantations, L. C. Miller, 1904.

Locust, black.

Age.	Diameter growth.					
	Close stand.		Broken stand.		Open stand.	
	Northeastern Kentucky.[a]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inchse.*		*Inches.*	
10 years	2.7	15 stumps 20 to 42 years old.	3.8	24 stumps 9 to 38 years old.	5.0	15 stumps 10 to 28 years old.
20 years	5.2		6.8		9.3	
30 years	7.1		9.0		....	
40 years	8.7		10.7		....	

[a] Forest conditions in Kentucky, J. S. Holmes, 1908.

Maple, red.

Age.	Diameter growth.	
	Dutchess County, N. Y.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years	1.6	5-year measurements on 25 4.5-foot stumps 12 to 67 years old.
20 years	3.1	
30 years	4.5	
40 years	5.8	
50 years	7.0	
60 years	8.0	
70 years	8.0	

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.

Maple, silver.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.	5-year measurements on 11 1-foot stumps 16 to 34 years old.	*Feet.*	7-foot sections on 11 trees 16 to 34 years old.
			22	
10 years	3.1		44	
20 years	5.1		60	
30 years	7.5		72	
40 years	9.0		80	

[a] Plantations, L. C. Miller, 1904.

Maple, sugar.

Age.	Diameter growth.			
	Leelanau County, Mich.[a]		Franklin County, N. Y.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.	Decade measurements on 261 2.1 to 3 foot stumps 64 to 214 years old.	*Inches.*	548 trees with stumps of various heights and diameters.
10 years	0.2		0.6	
20 years	1.0		1.3	
30 years	1.9		1.9	
40 years	2.8		2.7	
50 years	3.8		3.5	
60 years	4.9		4.3	
70 years	5.9		5.2	
80 years	7.0		6.0	
90 years	8.0		6.9	
100 years	9.0		7.8	
110 years	10.1		8.8	
120 years	11.1		9.8	
130 years	12.1		10.9	
140 years	13.1		11.9	
150 years	14.0		12.9	
160 years	14.8		14.0	
170 years	15.6		15.0	
180 years	16.4		16.0	
190 years	17.1		16.9	
200 years	17.7		17.8	
210 years	....		18.6	
220 years	....		19.5	
230 years	....		20.3	
240 years	....		21.0	
250 years	....		21.6	
260 years	....		22.7	
270 years	....		23.4	
280 years	....		24.2	
290 years	....		25.0	
300 years	....		25.7	

[a] Newhall Working Plan, by S. J. Record, 1905.
[b] St. Regis Tract, O. W. Price, 1899.

Oak, black.

Age.	Diameter growth.							
	Slope.		Cove and slope.		Ridge.		Upland and bottom.	
	Polk and Monroe counties, Tenn.[a]		Tennessee.[b]		Tennessee.[b]		Lyon County, Ky.[c]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	....	Decade measurements on 148 2-foot stumps 40 to 200 years old.	1.4	Decade measurements on 149 2-foot stumps 33 to 124 years old.	1.4	Decade measurements on 166 2-foot stumps 37 to 85 years old.	2.1	Decade measurements of 188 trees with varying stumps 23 to 172 years old.
20 years	1.8		3.8		4.0		4.4	
30 years	3.7		6.6		6.8		6.9	
40 years	5.7		9.3		9.5		9.4	
50 years	7.7		11.5		11.3		11.3	
60 years	9.3		13.0		12.4		12.6	
70 years	10.8		13.9		13.3		13.4	
80 years	12.2		14.7		14.2		13.8	
90 years	13.4		15.3		14.9		14.2	
100 years	14.4		....		....		14.4	
110 years	15.5		....		....		14.6	
120 years	16.6		....		....		....	
130 years	17.6		....		....		....	
140 years	18.5		....		....		....	
150 years	19.4		....		....		....	
160 years	20.2		....		....		....	
170 years	21.0		....		....		....	
180 years	21.7		....		....		....	
190 years	22.5		....		....		....	
200 years	23.3		....		....		....	

Oak, black and scarlet.

Age.	Diameter growth.						Height growth.	
	Seedling.				Coppice.		Ridge.	
	Laclede County, Mo.[d]		Dutchess County, N. Y.[e] [f]				Tennessee.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Inches.*		*Feet.*	
10 years	0.6	Decade measurements on 51 4.5-foot stumps 23 to 63 years old.	0.5	5-year measurements on 40 4.5-foot stumps 21 to 68 years old.	1.7	5-year measurements on 77 4.5-foot stumps 11 to 65 years old.	16	944 entries 1 to 85 years old.
20 years	2.6		2.2		3.4		29	
30 years	4.4		3.8		4.9		40	
40 years	6.2		5.3		6.2		51	
50 years	....		6.7		7.2		61	
60 years	....		7.7		8.2		70	
70 years	....		8.5		9.0		77	
80 years	....		....		....		83	
90 years	....		....		....		....	
100 years	....		....		....		....	
110 years	....		....		....		....	
120 years	....		....		....		....	
130 years	....		....		....		....	
140 years	....		....		....		....	
150 years	....		....		....		....	
160 years	....		....		....		....	
170 years	....		....		....		....	
180 years	....		....		....		....	
190 years	....		....		....		....	
200 years	....		....		....		....	

[a] Wetmore and Stevenson Lands, F. E. Olmsted, 1901.
[b] Commercial Tree Study, Walter Mulford, 1905-6.
[c] Hillman Land and Iron Company, A. B. Patterson, 1905.
[d] Forest Conditions in Missouri, S. J. Record, 1906.
[e] Rogers and Huyler Working Plan, J. G. Peters, 1905.
[f] On White Oak Type.

Oak, chestnut.

Age.	Diameter growth.							
	Coppice.		Cove.		Slope.		Ridge.	
	Dutchess County, N. Y.[a] [b]		Polk and Monroe counties, Tenn.[c]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	2.1	5-year measurements on 53 4.5-foot stumps 12 to 67 years old.	....	Decade measurements on 26 2 to 3.5 foot stumps 89 to 200 years old.	....	Decade measurements on 93 1.5 to 4.5 foot stumps 103 to 200 years old.	....	Decade measurements on 24 1.5 to 4.1 foot stumps 89 to 199 years old.
20 years	3.9		1.7		1.2		0.9	
30 years	5.3		3.7		2.4		1.9	
40 years	6.6		5.6		3.4		2.9	
50 years	7.6		7.3		4.3		4.0	
60 years	8.4		8.9		5.4		5.1	
70 years	9.1		10.3		6.5		6.2	
80 years	....		11.6		7.7		7.4	
90 years	....		12.8		8.8		8.6	
100 years	....		13.9		10.0		9.8	
110 years	....		15.0		10.9		11.0	
120 years	....		16.0		12.0		12.2	
130 years	....		17.0		13.0		13.4	
140 years	....		18.0		13.9		14.4	
150 years	....		19.0		14.9		15.3	
160 years	....		19.8		15.8		16.0	
170 years	....		20.6		16.7		16.7	
180 years	....		21.3		17.5		17.2	
190 years	....		22.1		18.4		17.6	
200 years	....		22.8		19.3		18.0	

Age.	Diameter growth.				Height growth.			
	Cove, slope, ridge.		Ridge.		Cove and slope.		Ridge.	
	Tennessee.[d]		Jackson County, Ky.[d]		Tennessee.[d]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	1.2	Decade measurements on 44 1.5 to 4.1 foot stumps 4 to 86 years old.	....	Decade measurements on 161 4.5-foot stumps 78 to 200 years old.	14	120 trees 1 to 86 years old.	14	27 trees 2 to 73 years old.
20 years	3.1		0.7		28		29	
30 years	5.1		1.6		40		40	
40 years	7.1		2.5		49		47	
50 years	8.9		3.4		57		53	
60 years	9.9		4.3		61		58	
70 years	10.4		5.2		63		61	
80 years	10.6		6.1		63		....	
90 years	10.9		7.0		....		....	
100 years	....		7.9		....		....	
110 years	....		8.9		....		....	
120 years	....		9.9		....		....	
130 years	....		10.8		....		....	
140 years	....		11.9		....		....	
150 years	....		12.9		....		....	
160 years	....		13.9		....		....	
170 years	....		14.8		....		....	
180 years	....		15.7		....		....	
190 years	....		16.5		....		....	
200 years	....		17.4		....		....	

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[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.
[b] On Chestnut Oak Type.
[c] Wetmore and Stevenson Lands, F. E. Olmsted, 1901.
[d] Commercial Tree Study, Walter Mulford, 1905-6.

Oak, red.

Age.	Diameter growth.					
	Slope.		Cove and slope.		Upland and bottom.	
	Swain County, N. C.[a]		Tennessee.[a]		Lyon County, Ky.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*	
10 years	0.2	Decade measurements on 358 3-foot stumps 71 to 200 years old.	1.1	Decade measurements on 32 2.5-foot stumps 47 to 76 years old.	2.2	Decade measurements on 223 trees of varying stumps 20 to 132 years old.
20 years	1.5		3.6		5.0	
30 years	2.8		6.9		7.6	
40 years	4.4		10.3		10.3	
50 years	5.9		12.7		12.4	
60 years	7.5		14.1		14.1	
70 years	9.3		15.0		15.4	
80 years	11.3		15.5			
90 years	13.3		15.8			
100 years	15.3					
110 years	17.1					
120 years	18.7					
130 years	20.3					
140 years	21.6					
150 years	22.7					
160 years	23.8					
170 years	24.8					
180 years	25.8					
190 years	26.8					
200 years	27.6					

Age.	Diameter growth.		Height growth.	
	Coppice.		Cove and slope.	
	Dutchess County, N. Y.[c][d]		Tennessee.[a]	
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	2.0	Decade measurements on 10 2-foot stumps 62 to 76 years old.	13	99 trees 2 to 76 years old.
20 years	4.1		32	
30 years	6.1		46	
40 years	8.0		60	
50 years	9.8		72	
60 years	11.5		80	
70 years			87	
80 years				
90 years				
100 years				
110 years				
120 years				
130 years				
140 years				
150 years				
160 years				
170 years				
180 years				
190 years				
200 years				

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[a] Commercial Tree Study, Walter Mulford, 1905–6.
[b] Hillman Land and Iron Company, A. B. Patterson, 1905.
[c] Rogers and Huyler Working Plan, by J. G. Peters, 1905.
[d] On Chestnut Oak Type.

Oak, white.

Age.	Diameter growth.							
	Crawford County, Mo.[a]		Second growth.		Seedling.		Coppice.	
			Logan County, W. Va.[b]		Dutchess County, N. Y.[c d]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	....	Decade measurements on 73 2.5-foot stumps 113 to 280 years old.	1.5	Decade measurements on 34 4.5-foot stumps 17 to 97 years old.	....	5-year measurements on 29 4.5-foot stumps 15 to 80 years old.	1.9	5-year measurements on 29 4.5-foot stumps 8 to 72 years old.
20 years	1.1		3.1		2.2		3.9	
30 years	2.2		4.4		4.1		5.4	
40 years	3.2		5.4		5.7		6.6	
50 years	4.2		6.3		7.1		7.6	
60 years	5.2		7.2		8.2		8.4	
70 years	6.2		7.9		9.1		9.1	
80 years	7.2		8.6		....		....	
90 years	8.2		9.3		....		....	
100 years	9.1		10.0		....		....	
110 years	10.0		....		....		....	
120 years	10.9		....		....		....	
130 years	11.7		....		....		....	
140 years	12.5		....		....		....	
150 years	13.4		....		....		....	
160 years	14.2		....		....		....	
170 years	15.0		....		....		....	
180 years	15.8		....		....		....	
190 years	16.6		....		....		....	
200 years	17.5		....		....		....	
210 years	....		....		....		....	
220 years	....		....		....		....	
230 years	....		....		....		....	
240 years	....		....		....		....	

[a] Forest Conditions in Missouri, S. J. Record, 1906.
[b] United States Coal and Oil Lands, R. C. Hawley, 1904.
[c] Rogers and Huyler Working Plan, J. G. Peters, 1905.
[d] On white oak type.

Oak, white—Continued.

Age.	Diameter growth.							
	Upland and bottom.		Slope.				Cove.	
	Lyon County, Ky.[a]		Jackson County, Ky.[b]		Polk and Monroe counties, Tenn.[c]		Scott, Campbell, and Anderson counties, Tenn.[d]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.4	Decade measurements of 180 trees with varying stumps 22 to 242 years old.	([e])	Decade measurements on 507 2-foot stumps 143 to 200 years old.	....	Decade measurements on 56 2.5 to 3.4 foot stumps 119 to 312 years old.	....	Decade measurements on 132 3-foot stumps 145 to 250 years old.
20 years	3.6		1.1		0.7		0.9	
30 years	5.6		2.2		1.7		2.0	
40 years	7.3		3.2		2.6		3.0	
50 years	8.7		4.2		3.4		4.1	
60 years	9.8		5.3		4.3		5.1	
70 years	10.6		6.3		5.3		6.0	
80 years	11.2		7.4		6.3		7.1	
90 years	11.7		8.5		7.2		8.1	
100 years	12.2		9.7		8.1		9.1	
110 years	12.7		11.0		9.1		10.3	
120 years	13.1		12.3		10.1		11.4	
130 years	13.5		13.5		11.1		12.5	
140 years	13.9		14.7		12.0		13.7	
150 years	14.4		15.4		13.0		14.8	
160 years	....		16.8		14.0		16.1	
170 years	....		17.8		14.9		17.3	
180 years	....		18.9		15.8		18.5	
190 years	....		19.9		16.5		19.7	
200 years	....		21.0		17.1		20.8	
210 years	....		....		....		21.9	
220 years	....		....		....		22.9	
230 years	....		....		....		23.8	
240 years	....		....		....		24.7	

[a] Hillman Land and Iron Company, A. B. Patterson, 1905.
[b] Commercial Tree Study, Walter Mulford, 1905-6.
[c] Wetmore and Stevenson Lands, F. E. Olmsted, 1901.
[d] New River Tract, F. E. Olmsted, 1901.
[e] A good average for the southern Appalachian region.

Oak, white—Continued.

Age.	Diameter growth (second).				Height growth (second).			
	Cove and slope.		Ridge.		Cove and slope.		Ridge.	
	Decatur County, Tenn.[a] [b]				Decatur County, Tenn.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	0.9	Decade measurements on 52 2-foot stumps 49 to 108 years old.	1.3	Decade measurements on 11 2.5-foot stumps 47 to 86 years old.	12	357 entries 1 to 108 years old.	11	46 entries 1 to 86 years old.
20 years	3.3		3.4		25		22	
30 years	5.9		5.7		38		32	
40 years	8.3		8.0		51		43	
50 years	10.3		10.0		63		53	
60 years	11.7		11.5		71		63	
70 years	12.6		12.7		75		70	
80 years	13.3		13.4		77		75	
90 years	13.5		14.0		78		78	
100 years	....		....		....		....	
110 years	....		....		....		....	
120 years	....		....		....		....	
130 years	....		....		....		....	
140 years	....		....		....		....	
150 years	....		....		....		....	
160 years	....		....		....		....	
170 years	....		....		....		....	
180 years	....		....		....		....	
190 years	....		....		....		....	
200 years	....		....		....		....	
210 years	....		....		....		....	
220 years	....		....		....		....	
230 years	....		....		....		....	
240 years	....		....		....		....	

[a] Commercial Tree Study, Walter Mulford, 1905-6.
[b] Circular 105, p. 22.

Oak, swamp white.

Age.	Diameter growth.			
	Seedling.		Coppice.	
	Dutchess County, N. Y.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	0.5	5-year measurements on 8 3.5-foot stumps 44 to 111 years old.	2.3	5-year measurements on 8 4.5-foot stumps 27 to 63 years old.
20 years	2.7		4.5	
30 years	4.4		6.2	
40 years	5.9		7.6	
50 years	7.1		9.0	
60 years	8.3		10.3	
70 years	9.3		....	
80 years	10.2		....	
90 years	....		....	

[a] Rogers and Huyler Working Plan, by J. G. Peters, 1905.

Pine, loblolly.

Age.	Diameter growth.							
	Thicket.					Old field.		
	Berkeley County, S. C.[a]		Eastern Texas.[b]	Calhoun County, Ark.[c]		Berkeley County, S. C.[d]	Eastern Texas.[b] [e]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Diameter breast-high.	Basis.	Diameter breast-high.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	*Inches.*		*Inches.*	*Inches.*	
10 years	1.0	Decade measurements on 476 2.5-foot stumps 54 to 179 years old.	0.8	1.0	Decade measurements on 673 2-foot stumps 35 to 181 years old.	1.4	4.3	Five-year measurements on 24 trees 5 to 29 years old.
20 years	4.0		2.3	3.1		6.1	7.6	
30 years	7.4		3.9	5.0		10.0	9.3	
40 years	10.5		5.7	6.9		13.3	....	
50 years	13.0		7.8	8.8		15.9	....	
60 years	14.9		10.1	10.7		18.1	....	
70 years	16.4		11.5	12.4		19.9	....	
80 years	17.7		13.4	14.1		21.5	....	
90 years	18.9		15.5	15.6		23.0	....	
100 years	20.0		17.3	17.2		24.5	....	
110 years	21.1		18.7	18.7		25.9	....	
120 years	22.0		19.8	20.2		27.2	....	
130 years	....		20.8	21.6		28.5	....	
140 years	....		21.8	22.9		29.7	....	
150 years	....		22.8	24.2		30.7	....	
160 years	....		23.7	25.5		31.7	....	
170 years	....		24.5	....		32.6	....	
180 years	....		25.3	....		33.5	....	
190 years	....		25.9	....		34.3	....	
200 years	....		26.5	....		35.1	....	
210 years	....		27.1	....		35.8	....	
220 years	....		27.6	....		36.5	....	
230 years	....		28.1	....		37.2	....	
240 years	....		28.6	....		37.8	....	
250 years	....		29.1	....		38.5	....	

[a] Cooper River Holdings—Wassamassaw Tract, H. G. Merrill, 1906.
[b] Loblolly Pine Study, by R. Zon, 1903–4.
[c] Stout-Greer Working Plan, by S. J. Record, 1907.
[d] Cooper River Holdings, C. S. Chapman, 1902–3.
[e] Orange, Newton, Montgomery, and San Jacinto counties, Tex.

Pine, loblolly—Continued.

Age.	Diameter growth.								Height growth.	
	Pure stand on wet prairie.		Pure stand on light soil fairly well drained (prairie).		Mixed with hard woods on poorly drained soil (thicket).		Mixed with hard woods on well drained fertile soil.			
	Eastern Texas.[b]								Berkeley County, S. C.[a]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	In.		*In.*		*In.*		*In.*		*Feet.*	
10 years	3.7	Five-year measurements on 10 trees 23 to 41 years old.	2.2	Five-year measurements on 30 trees 35 to 72 years old.	0.9	Five-year measurements on 30 trees 54 to 247 years old.	2.1	Five-year measurements on 499 trees 16 to 101 years old.	12	Combination of height on diameter breast-high and diameter breast-high on age.
20 years	6.7		7.6		2.2		6.1		38	
30 years	8.8		12.8		3.8		9.5		59	
40 years	......		16.9		5.6		12.4		75	
50 years	......		20.0		7.8		15.0		86	
60 years	......		22.3		9.8		17.2		94	
70 years	......		24.0		11.9		19.3		100	
80 years	......		......		13.9		......		104	
90 years	......		......		15.8		......		108	
100 years	......		......		17.4		......		111	
110 years	......		......		18.8		......		114	
120 years	......		......		20.0		......		117	
130 years	......		......		20.9		......		119	
140 years	......		......		21.8		......		121	
150 years	......		......		22.6		......		122	
160 years	......		......		23.3		......		123	
170 years	......		......		24.0		......		124	
180 years	......		......		24.7		......		124	
190 years	......		......		25.3		......		125	
200 years	......		......		25.8		......		125	
210 years	......		......		26.3		......		126	
220 years	......		......		26.8		......		126	
230 years	......		......		27.2		......		126	
240 years	......		......		27.6		......		127	
250 years	......		......		......		......		127	

[a] Cooper River Holdings, C. S. Chapman, 1902-3.
[b] Loblolly Pine Study, by R. Zon, 1903-4.

Pine, longleaf.

Age.	Diameter growth.						
	Coosa County, Ala.[a]		Berkeley County, S. C.[b]	Berkeley County, S. C.[c]		Jasper County, Tex[d]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	*Inches.*		*Inches.*	
10 years	....	Decade measurements on 265 stumps of various heights and diameters.	....	0.8	Decade measurements on 234 2.5-foot stumps 70 to 204 years old	....	Decade measurements on 1,292 stumps of various heights and diameters.
20 years	1.4		1.2	2.2		1.5	
30 years	2.8		3.0	3.9		3.0	
40 years	4.5		4.9	5.5		4.7	
50 years	6.2		6.7	7.1		6.3	
60 years	7.9		8.6	8.5		8.0	
70 years	9.6		10.5	10.0		9.5	
80 years	11.2		12.4	11.3		10.9	
90 years	12.6		14.1	12.6		12.2	
100 years	14.0		15.5	13.9		13.3	
110 years	15.2		16.6	15.1		14.3	
120 years	16.3		17.6	16.4		15.3	
130 years	17.4		18.4	17.6		16.3	
140 years	18.5		19.2	18.7		17.1	
150 years	19.6		20.0	19.6		17.9	
160 years	20.6		20.7	20.4		18.7	
170 years	21.5		21.4	21.0		19.4	
180 years	22.4		22.2	21.5		20.0	
190 years	23.2		22.9	21.8		20.7	
200 years	24.0		23.6	22.5		21.4	
210 years	24.7		24.3	....		22.1	
220 years	25.4		25.0	....		22.7	
230 years	26.0		25.6	....		23.4	
240 years	26.7		26.3	....		24.0	
250 years	27.3		26.9	....		24.7	
260 years	27.9		....	....		25.4	
270 years	28.5		....	....		26.1	
280 years	29.1		....	....		26.7	
290 years	29.7		....	....		27.4	
300 years	30.3		....	....		28.1	
310 years	....		....	....		28.8	
320 years	....		....	....		29.4	
330 years	....		....	....		29.9	
340 years	....		....	....		30.5	
350 years	....		....	....		31.0	
360 years	....		....	....		31.6	
370 years	....		....	....		32.0	
380 years	....		....	....		32.6	
390 years	....		....	....		33.1	
400 years	....		....	....		33.6	

[a] Kaul Tract, F. W. Reed, 1903–4.
[b] Cooper River Holdings, C. S. Chapman, 1902–3.
[c] Cooper River Holdings, Wassamasaw Tract, H. G. Merrill, 1906.
[d] Houston Oil Lands, by F. W. Reed, G. E. Clement, H. M. Curran, A. E. Cohoon, 1902–3.

Pine, longleaf—Continued.

Age.	Diameter growth (second).							
	Jasper County, Tex.[a]				Newton County, Tex.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
20 years	1.6	Decade measurements on 1,530 stumps of various heights and diameters.	1.5	Decade measurements on 507 2-foot stumps 21 to 91 years old	1.5	Decade measurements on 907 stumps of various heights and diameters.	2.8	Decade measurements on 65 2-foot stumps 12 to 117 years old
30 years	3.4		3.1		3.0		5.8	
40 years	5.2		4.9		4.4		8.4	
50 years	7.1		6.8		6.0		10.4	
60 years	8.7		8.6		7.3		11.6	
70 years	10.1		10.1		8.7		12.7	
80 years	11.3		11.5		10.1		13.7	
90 years	12.4		12.8		11.3		14.5	
100 years	13.3		13.9		12.5		15.2	
110 years	14.2		......		13.5		15.8	
120 years	15.0		......		14.4		16.3	
130 years	16.0		......		15.3		......	
140 years	16.9		......		16.2		......	
150 years	17.8		......		17.0		......	
160 years	18.8		......		17.9		......	
170 years	19.8		......		18.5		......	
180 years	20.8		......		19.1		......	
190 years	21.8		......		19.7		......	
200 years	22.8		......		20.3		......	
210 years	23.5		......		20.9		......	
220 years	24.2		......		21.5		......	
230 years	24.8		......		22.2		......	
240 years	25.4		......		22.9		......	
250 years	25.9		......		23.5		......	
260 years	26.4		......		24.0		......	
270 years	27.0		......		24.5		......	
280 years	27.8		......		24.9		......	
290 years	28.4		......		25.2		......	
300 years	29.2		......		25.7		......	
310 years	30.0		......		26.0		......	
320 years	30.9		......		26.4		......	
330 years	31.8		......		26.9		......	
340 years	32.8		......		27.4		......	
350 years	33.9		......		28.0		......	
360 years	35.0		......		28.4		......	
370 years	36.2		......		29.0		......	
380 years	37.3		......		29.6		......	
390 years	38.5		......		30.1		......	
400 years	39.6		......		30.7		......	

[a] Houston Oil Lands, by F. W. Reed, G. E. Clement, H. M. Curran, A. E. Cohoon, 1902-3.

Pine, longleaf—Continued.

Age.	Diameter growth.				Height growth.			
	Hardin County, Tex.[a]		Jasper, Hardin, and Newton counties, Tex.[b]		Berkeley County, S. C.[b]		Jasper, Hardin, and Newton counties, Tex.[a]	
							Camp W.	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	......	Decade measurements on 1,918 stumps of various heights and diameters.	......	Decade measurements on 5,656 stumps of various heights and diameters.	4	Combination of height on diameter breast-high and diameter breast-high on age.	9	Combination of height on diameter breast-high and diameter breast-high on age.
20 years	1.8		1.7		17		21	
30 years	3.5		3.3		29		36	
40 years	5.2		5.0		41		50	
50 years	7.0		6.6		52		63	
60 years	8.7		8.2		62		74	
70 years	10.2		9.6		71		82	
80 years	11.6		10.8		78		88	
90 years	12.6		12.0		83		92	
100 years	13.6		13.1		86		95	
110 years	14.6		14.2		89		97	
120 years	15.4		15.1		91		99	
130 years	16.1		16.0		93		100	
140 years	16.8		16.8		94		101	
150 years	17.5		17.6		95		102	
160 years	18.2		18.3		96		103	
170 years	18.8		19.0		97		104	
180 years	19.4		19.8		98		104	
190 years	20.0		20.5		99		105	
200 years	20.5		21.2		100		105	
210 years	21.0		21.9		101		106	
220 years	21.4		22.6		101		107	
230 years	21.9		23.2		102		107	
240 years	22.5		23.9		103		107	
250 years	23.1		24.5		103		107	
260 years	23.9		25.1		......		108	
270 years	24.6		25.7		......		108	
280 years	25.4		26.3		......		109	
290 years	26.1		26.9		......		109	
300 years	26.8		27.5		......		109	
310 years	27.5		28.0		......		110	
320 years	28.1		28.6		......		110	
330 years	28.5		29.1		......		110	
340 years	28.9		29.6		......		110	
350 years	29.3		30.2		......		111	
360 years	29.8		30.7		......		111	
370 years	30.2		31.2		......		112	
380 years	30.5		31.7		......		112	
390 years	30.9		32.2		......		113	
400 years	31.3		32.6		......		113	

[a] Houston Oil Lands, by F. W. Reed, G. E. Clement, H. M. Curran, A. E. Cohoon, 1902-3.
[b] Cooper River Holdings, C. S. Chapman, 1902-3.

Pine, longleaf—Continued.

Age.	Height growth.							
	Jasper, Hardin, and Newton counties, Tex.[a]							
	Camp X.		Camp Y.		Camp Z.		All camps.	
	Height.	Basis.	Height.	Basis.	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*		*Feet.*		*Feet.*	
10 years	7	Combination of height on diameter breast-high and diameter breast-high on age.	11	Combination of height on diameter breast-high and diameter breast-high on age.	7	Combination of height on diameter breast-high and diameter breast-high on age.	9	Combination of height on diameter breast-high and diameter breast-high on age.
20 years	15		23		15		19	
30 years	27		39		25		32	
40 years	38		54		35		45	
50 years	49		67		45		56	
60 years	60		78		54		67	
70 years	69		86		62		75	
80 years	77		92		69		82	
90 years	83		95		76		87	
100 years	88		98		83		91	
110 years	92		99		88		94	
120 years	95		100		92		97	
130 years	98		101		96		99	
140 years	101		102		100		101	
150 years	103		102		103		103	
160 years	105		103		106		104	
170 years	107		104		107		106	
180 years	109		105		108		107	
190 years	110		106		109		108	
200 years	111		107		110		109	
210 years	112		108		110		110	
220 years	113		109		111		110	
230 years	113		109		112		111	
240 years	114		110		113		111	
250 years	114		110		114		112	
260 years	114		110		114		112	
270 years	114		110		115		112	
280 years	114		110		116		113	
290 years	115		110		116		113	
300 years	115		111		117		113	
310 years	116		111		117		114	
320 years	116		111		118		114	
330 years	116		111		118		115	
340 years	117		111		119		115	
350 years	117		111		119		115	
360 years	117		111		120		116	
370 years	118		111		120		116	
380 years	118		111		121		116	
390 years	118		111		121		116	
400 years	118		111		122		116	

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[a] Houston Oil Lands, by F. W. Reed, G. E. Clement, H. M. Curran, A. E. Cohoon, 1902-3.

Pine, jack.

Age.	Diameter growth.							
	Class A; quality, good, subdominant.		Quality, good, medium.		Quality, good, suppressed.		Quality, poor, subdominant.	
	Hubbard County, Minn.[a]							
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.7	Decade measurements on 44 4.5-foot stumps 22 to 49 years old.	1.4	Decade measurements on 45 4.5-foot stumps 22 to 46 years old.	1.2	Decade measurements on 45 4.5-foot stumps 18 to 46 years old.	1.0	Decade measurements on 83 4.5-foot stumps 22 to 81 years old.
20 years	4.4		3.8		3.0		3.3	
30 years	6.2		5.1		4.0		4.8	
40 years	7.5		6.1		4.7		6.0	
50 years	8.5		7.0		....		7.0	
60 years	....		....		....		7.8	
70 years	....		....		....		8.6	
80 years	....		....		....		9.3	

Age.	Diameter growth.									
	Quality, poor, medium.		Quality, poor, suppressed.		Classes B and C; quality, good, dominant.		Quality, poor, dominant.		Class D; open grown.	
	Hubbard County, Minn.[a]									
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*		*Inches.*	
10 years	0.9	Decade measurements on 80 4.5-foot stumps 20 to 76 years old.	0.8	Decade measurements on 82 4.5-foot stumps 21 to 80 years old.	1.8	Decade measurements on 74 4.5-foot stumps 23 to 90 years old.	1.1	Decade measurements on 91 4.5-foot stumps 22 to 102 years old.	1.7	Decade measurements on 60 4.5-foot stumps 22 to 82 years old.
20 years	2.8		2.2		5.5		3.9		5.1	
30 years	4.2		3.2		7.9		5.9		7.9	
40 years	5.1		4.1		9.4		7.4		10.2	
50 years	6.0		4.9		10.8		8.7		11.8	
60 years	6.5		5.5		......		9.9		13.1	
70 years	7.1		6.1		......		10.9		14.2	
80 years	7.5		......		......		11.8		15.3	

[a] Northern Pacific Railroad Tie Study, by H. H. Chapman, 1905.

Pine, red.

Age.	Diameter growth.							
	Ridge.		Ravine.		Jack pine mixture; quality, good.		Jack pine mixture; quality, poor.	
	Bayfield County, Wis.[a]				Itasca County, Minn.[a]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	0.5	Decade measurements on 140 1-foot stumps 111 to 202 years old.	1.0	Decade measurements on 99 1-foot stumps 108 to 203 years old.	0.4	Decade measurements on 26 2.5-foot stumps 21 to 44 years old.	....	Decade measurements on 18 2.5-foot stumps 19 to 77 years old.
20 years	2.7		3.3		2.4		1.7	
30 years	5.2		5.8		4.2		3.4	
40 years	7.5		8.2		5.7		4.8	
50 years	9.3		10.3		....		6.0	
60 years	11.0		12.1		....		6.9	
70 years	12.5		13.8		....		7.8	
80 years	13.7		15.3		....		....	
90 years	14.8		16.5		....		....	
100 years	15.9		17.6		....		....	
110 years	17.0		18.7		....		....	
120 years	18.0		19.7		....		....	
130 years	19.1		20.7		....		....	
140 years	20.2		21.7		....		....	
150 years	21.2		22.6		....		....	
160 years	22.2		23.4		....		....	
170 years	23.1		24.2		....		....	
180 years	24.0		24.9		....		....	
190 years	24.9		25.5		....		....	
200 years	25.7		26.1		....		....	

Age.	Diameter growth.					
	Classes 2A and 4.[b]		Classes 1, 2B, and 3; open grown and dominant.		Class 2.	
	Itasca County, Minn.[a]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*	
10 years	0.3	Decade measurements on 228 1 to 1.5 foot stumps 72 to 126 years old.	0.9	Decade measurements on 190 1 to 1.5 foot stumps 78 to 163 years old.	0.2	Decade measurements on 52 1 to 1.5 foot stumps 84 to 107 years old.
20 years	2.0		3.6		1.2	
30 years	3.9		6.5		2.0	
40 years	5.7		9.0		3.1	
50 years	7.3		11.1		4.2	
60 years	8.7		12.7		5.6	
70 years	10.0		13.9		7.2	
80 years	11.1		15.0		9.0	
90 years	12.1		16.0		10.9	
100 years	12.8		16.9		12.9	
110 years	13.5		17.9		....	
120 years	14.0		18.8		....	
130 years	14.5		19.7		....	
140 years	....		20.6		....	
150 years	....		21.5		....	
160 years	....		22.3		....	
170 years	....		....		....	
180 years	....		....		....	
190 years	....		....		....	
200 years	....		....		....	

[a] Red Pine Study, by H. H. Chapman, 1905.

[b] Averages of crowded stands.

Pine, scrub.

Age.	Diameter growth.				Height growth.			
	Dominant.		Intermediate and suppressed.					
	Montgomery County, Md.[a]							
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*		*Feet.*	
10 years	2.4	104 trees 5 to 56 years old.	1.9	42 trees 5 to 56 years old.	17	801 sectional age counts (about 200 trees).	25	Combined growth-diameter (dominant trees) and height curves.
20 years	2.8		3.6		33		42	
30 years	6.5		4.8		46		48	
40 years	7.9		5.5		55		52	
50 years	8.9		6.2		63		54	
60 years	10.1		....		....		56	

[a] Scrub Pine Study, by W. D. Sterrett, 1905.

Pine, shortleaf.

Age.	Diameter growth.			
	Calhoun County, Ark.[a]		Reynolds County, Mo.[a]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
10 years	0.8	Decade measurements on 398 2-foot stumps 48 to [illegible] years old.	....	Decade measurements on 231 2-foot stumps 102 to 254 years old.
20 years	2.5		1.6	
30 years	4.2		3.4	
40 years	5.8		5.1	
50 years	7.5		6.7	
60 years	9.0		8.2	
70 years	10.4		9.6	
80 years	11.9		10.7	
90 years	13.2		11.8	
100 years	14.6		12.7	
110 years	15.8		13.6	
120 years	16.9		14.4	
130 years	18.0		15.2	
140 years	18.9		15.9	
150 years	19.8		16.6	
160 years	20.6		17.3	
170 years	21.3		18.0	
180 years	22.0		18.8	
190 years	22.7		....	
200 years	23.4		....	

[a] Stout-Greer Working Plan, by S. J. Record, 1907.

Pine, spruce.

Age.	Diameter growth.	
	Berkeley County, S. C.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years		
20 years	1.4	Decade measurements on 70 2.5-foot stumps 78 to 127 years old.
30 years	3.3	
40 years	5.6	
50 years	8.1	
60 years	10.7	
70 years	13.2	
80 years	15.7	
90 years	17.9	
100 years	19.4	
110 years	20.6	
120 years	21.7	

[a] Cooper River Holdings, Wassamasaw Tract, H. G. Merrill, 1906.

Pine, sugar.

Age.	Diameter growth.		Height growth.	
	Butte County, Cal.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	0.7	Decade measurements on 144 2.5-foot stumps 25 to 311 years old.	7	Combination of growth-diameter and height curves.
20 years	2.5		15	
30 years	4.1		22	
40 years	5.8		29	
50 years	7.8		39	
60 years	9.9		49	
70 years	12.2		60	
80 years	14.4		70	
90 years	16.5		81	
100 years	18.7		92	
110 years	20.9		103	
120 years	23.0		113	
130 years	24.9		122	
140 years	26.6		128	
150 years	28.2		134	
160 years	29.3		138	
170 years	30.4		140	
180 years	31.4		143	
190 years	32.0		144	
200 years	32.4		144	

[a] Sugar Pine Study, by A. W. Cooper, 1904.

Pine, white.

Age.	Diameter growth.							
	Cove.				Slope.			
	St. Louis County, Minn.[a]		Johnson County, Tenn.[b]		Polk County, Tenn.[b]		Mitchell County, N. C.[b]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	......	Decade measurements on 8,764 stumps of various heights and diameters.	......	Decade measurements on 174 3-foot stumps 103 to 200 years old.	......	Decade measurements on 201 2-foot stumps.	0.2	Decade measurements on 504 2.5-foot stumps.
20 years	2.8		1.9		2.2		2.4	
30 years	5.3		5.6		4.4		4.7	
40 years	7.6		8.5		6.4		6.9	
50 years	9.2		11.3		8.5		9.1	
60 years	10.7		13.9		10.7		11.2	
70 years	11.9		16.5		12.7		13.2	
80 years	13.0		18.6		14.5		15.0	
90 years	13.9		20.5		16.1		16.6	
100 years	14.8		22.1		17.7		18.0	
110 years	15.5		23.6		19.1		19.3	
120 years	16.3		25.1		20.4		20.4	
130 years	17.0		26.3		21.7		21.5	
140 years	17.7		27.5		22.8		22.5	
150 years	18.3		28.7		23.8		23.5	
160 years	19.0		30.0		24.8		24.5	
170 years	19.5		31.1		25.8		25.5	
180 years	20.4		32.3		26.8		26.4	
190 years	21.0		33.4		27.7		27.2	
200 years	21.7		34.5		28.6		27.9	
210 years	22.4		......		......		......	
220 years	23.0		......		......		......	
230 years	23.5		......		......		......	
240 years	24.0		......		......		......	
250 years	24.5		......		......		......	
260 years	25.0		......		......		......	
270 years	25.4		......		......		......	
280 years	25.8		......		......		......	
290 years	26.2		......		......		......	
300 years	26.6		......		......		......	

[a] White Pine Study, by C. S. Chapman, 1903.

[b] Commercial Tree Study, by Walter Mulford, 1905–6.

Poplar, yellow.

Age.	Diameter growth.							
	Cove.							
	Polk and Monroe counties, Tenn.[a]		Scott, Campbell, and Anderson counties, Tenn.[a]		Haywood County, N. C.[a]		Wyoming County, W. Va.[a]	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.2	Decade measurements on 132 2.5-foot stumps 24 to 200 years old.	1.0	Decade measurements on 181 3-foot stumps 23 to 200 years old.	1.6	Decade measurements on 67 3-foot stumps 38 to 200 years old.	1.2	Decade measurements on 33 4.5-foot stumps 152 to 200 years old.
20 years	3.4		3.0		4.6		3.0	
30 years	5.4		5.0		7.7		4.7	
40 years	7.3		6.9		10.5		6.5	
50 years	8.9		8.7		12.8		8.0	
60 years	10.4		10.4		14.7		9.5	
70 years	11.9		12.1		16.1		10.9	
80 years	13.4		13.8		17.3		12.3	
90 years	14.9		15.5		18.5		13.8	
100 years	16.3		17.0		19.5		15.1	
110 years	17.7		18.5		20.3		16.4	
120 years	19.1		20.0		21.1		17.8	
130 years	20.3		21.4		21.7		19.1	
140 years	21.5		22.7		22.4		20.4	
150 years	22.7		23.9		23.0		21.6	
160 years	23.7		24.9		23.7		22.8	
170 years	24.6		25.8		24.3		23.8	
180 years	25.5		26.7		24.9		24.7	
190 years	26.3		27.5		25.5		25.7	
200 years	27.1		28.3		26.1		26.4	

Age.	Diameter growth.							
	Slope.		Quality I (seedlings).[b]		Quality II (seedlings).[b]		Sprouts.[b]	
	Wyoming County, W. Va.[a]		Fairfax County, Va.[c]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*		*Inches.*	
10 years	1.1	Decade measurements on 42 4.5-foot stumps 29 to 199 years old.	2.9	827 decade measurements on 207 1 to 2 foot stumps 10 to 71 years old.	1.9	925 decade measurements on 209 1 to 2 foot stumps 17 to 102 years old.	3.6	346 decade measurements on 95 1 to 2 foot stumps 17 to 102 years old.
20 years	3.8		6.5		4.6		7.4	
30 years	6.0		9.7		7.4		10.2	
40 years	7.4		12.6		10.2		12.7	
50 years	8.7		15.2		13.0		15.0	
60 years	9.8		17.3		15.8		....	
70 years	11.0		19.2		18.3		....	
80 years	12.0		....		20.6		....	
90 years	13.1		....		22.7		....	
100 years	14.1		....		24.6		....	
110 years	15.2		....		....		....	
120 years	16.3		....		....		....	
130 years	17.4		....		....		....	
140 years	18.5		....		....		....	
150 years	19.7		....		....		....	
160 years	20.4		....		....		....	
170 years	21.1		....		....		....	
180 years	21.8		....		....		....	
190 years	22.3		....		....		....	
200 years	22.5		....		....		....	

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[a] Commercial Tree Study, Walter Mulford, 1905–6.
[b] Taken in pure even-aged stands of normal or almost normal density.
[c] Second Growth Yellow Poplar Study, by W. W. Ashe, 1907.

Poplar, yellow—Continued.

Age.	Height growth.					
	Quality I (seedlings).		Quality II (seedlings).		Sprouts.	
	Fairfax County, Va.[a]					
	Height.	Basis.	Height.	Basis.	Height.	Basis.
	Feet.		*Feet.*		*Feet.*	
10 years	27	358 sectional age counts on 207 trees.	20	326 sectional age counts on 209 trees.	32	183 sectional age counts on 95 trees.
20 years	50		36		53	
30 years	64		50		70	
40 years	74		64			
50 years	83		78			
60 years						
70 years						
80 years						
90 years						
100 years						
110 years						
120 years						
130 years						
140 years						
150 years						
160 years						
170 years						
180 years						
190 years						
200 years						

[a] Second Growth Yellow Poplar Study, by W. W. Ashe, 1907.

Spruce, black.

Age.	Diameter growth.	
	St. Louis County, Minn.[a]	
	Diameter breast-high.	Basis.
	Inches.	
10 years		Decade measurements on 93 4.5-foot stumps 100 to 271 years old.
20 years		
30 years		
40 years	0.5	
50 years	1.1	
60 years	1.5	
70 years	1.9	
80 years	2.2	
90 years	2.4	
100 years	2.7	
110 years	2.9	

[a] White Pine Study, by C. S. Chapman, 1903.

Spruce, Engelmann.

Age.	Diameter growth.				Height growth.	
	Gunnison County, Colo.[a]		Uinta National Forest, Utah. Gunnison, Leadville, and Uncompahgre National Forests, Colo.[b]			
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Inches.*		*Feet.*	
10 years	....	Decade measurements at 2 feet on 43 trees 68 to 225 years old.	....	Decade measurements on 87 2-foot stumps 119 to 360 years old.		450 sectional age counts on 104 trees.
20 years	1.2		....		1.5	
30 years	2.3		....		2.5	
40 years	3.6		0.8		4.0	
50 years	4.8		1.6		5.5	
60 years	5.9		2.5		8.0	
70 years	7.0		3.4		11.0	
80 years	7.9		4.3		16.0	
90 years	8.7		5.2		22.0	
100 years	9.4		6.2		29.0	
110 years	10.0		7.0		36.0	
120 years	10.6		7.9		43.0	
130 years	11.1		8.6		50.0	
140 years	11.6		9.4		55.0	
150 years	12.1		10.1		60.0	
160 years	12.5		10.8		63.0	
170 years	12.9		11.5		66.0	
180 years	13.3		12.2		69.0	
190 years	13.7		12.9		72.0	
200 years	14.0		13.7		75.0	
210 years	....		....		78.0	
220 years	....		....		80.0	
230 years	....		....		83.0	
240 years	....		....		85.0	
250 years	....		....		90.0	

Age.	Height growth.				
	Gunnison County, Colo.[a]	Density 1.		Density 0.5.	
		Salt Lake National Forest, Idaho.[c d]			
	Height.	Height.	Basis.	Height.	Basis.
	Feet.	*Feet.*		*Feet.*	
10 years	2.2	1.3	9 trees.	1.0	10 trees.
20 years	4.0	3.8		3.0	
30 years	5.4	7.0		8.0	
40 years	6.7	10.0		12.5	
50 years	8.4	....		....	
60 years	10.2	....		....	
70 years	11.5	....		....	
80 years	12.3	....		....	
90 years	12.9	....		....	
100 years	13.5	....		....	
110 years	....	....		....	
120 years	....	....		....	
130 years	....	....		....	
140 years	....	....		....	
150 years	....	....		....	
160 years	....	....		....	
170 years	....	....		....	
180 years	....	....		....	
190 years	....	....		....	
200 years	....	....		....	
210 years	....	....		....	
220 years	....	....		....	
230 years	....	....		....	
240 years	....	....		....	
250 years	....	....		....	

[a] Planting Reconnoissance, S. B. Detweiler, 1906.
[b] Engelmann Spruce Study, by J. W. Foster, 1907.
[c] Planting Reconnoissance, J. M. Fetherolf.
[d] Pure conifer type, elevation 8,750 feet.

Spruce, red.

Age.	Diameter growth.			
	Piscataquis County, Me.[a]			
			Spruce slope—Quality II.	
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*	
20 years	0.1	Decade measurements on 274 1 to 2 foot stumps 112 to 300 years old.	0.6	Decade measurements on 39 4.5-foot stumps 49 to 197 years old.
30 years	0.6		2.4	
40 years	0.8		4.1	
50 years	1.1		5.3	
60 years	1.5		6.2	
70 years	1.8		6.8	
80 years	2.2		....	
90 years	2.7		....	
100 years	3.2		....	
110 years	3.7		....	
120 years	4.3		....	
130 years	4.9		....	
140 years	5.5		....	
150 years	6.2		....	
160 years	6.9		....	
170 years	7.6		....	
180 years	8.3		....	
190 years	9.0		....	
200 years	9.7		....	

[a] Maine Forest Study, R. S. Hosmer, 1902. Great Northern Paper Company, H. Grinnell, 1902.

Spruce, white.

Age.	Diameter growth.		Height growth.	
	St. Louis County, Minn.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	....	Decade measurements on 50 4.5-foot stumps 59 to 167 years old.	20	218 trees.
20 years	....		28	
30 years	....		43	
40 years	1.2		50	
50 years	2.5		....	
60 years	3.3		....	
70 years	4.2		....	
80 years	4.9		....	
90 years	5.6		....	
100 years	6.0		....	
110 years	6.5		....	
120 years	7.0		....	
130 years	7.5		....	
140 years	8.0		....	
150 years	8.8		....	
160 years	9.6		....	
170 years	10.5		....	

[a] White Pine Study, by C. S. Chapman, 1903.

Tamarack.

Age.	Diameter Growth.					
	Upland.				Swamp.	
	St. Louis County, Minn.[a]					
	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.	Diameter breast-high.	Basis.
	Inches.		*Inches.*		*Inches.*	
10 years	0.5	Decade measurements on 227 4.5-foot stumps 96 to 227 years old.	0.1	Decade measurements on 31 1.5 to 2 foot stumps 111 to 149 years old.	0.1	Decade measurements on 85 2-foot stumps 127 to 232 years old.
20 years	1.5		1.7		1.6	
30 years	2.5		3.4		2.9	
40 years	3.3		4.9		4.0	
50 years	4.2		6.1		5.0	
60 years	4.7		7.0		5.8	
70 years	5.3		7.8		6.4	
80 years	5.9		8.5		6.9	
90 years	6.5		9.2		7.4	
100 years	6.9		10.0		7.8	
110 years	7.5		10.8		8.4	
120 years	8.0		11.5		9.0	
130 years	8.6		12.3		9.7	
140 years	9.4		13.0		10.4	
150 years	10.6		13.7		11.0	
160 years	12.2		....		....	
170 years	13.4		....		....	
180 years	14.2		....		....	
190 years	15.0		....		....	
200 years	15.8		....		....	

[a] Northern Pacific Railroad Tie Study, by H. H. Chapman, 1905.

Walnut, black.

Age.	Diameter growth.		Height growth.	
	Eastern Nebraska.[a]			
	Diameter breast-high.	Basis.	Height.	Basis.
	Inches.		*Feet.*	
10 years	2.6	5-year measurements on 23 1-foot stumps 15 to 43 years old.	18	7-foot sectional measurements on 23 trees 15 to 43 years old.
20 years	5.2		30	
30 years	6.7		42	
40 years	7.5		51	
50 years	7.8		57	

[a] Plantations, L. C. Miller, 1904.

Birch, paper—Yield per acre—Pure (100 per cent) birch stands.

PENOBSCOT, PISCATAQUIS, SOMERSET, AND FRANKLIN COUNTIES, ME.

[Data gathered by R. L. Marston for Paper Birch Study 1903-1907.]

Age.	Quality I.				
	Average diameter breast-high.	Average height.	Total yield.	Yield of trees 6 inches and over, in percentage of total yield.	Basis.
	Inches.	*Feet.*	*Cubic feet.*	*Per cent.*	*Sample plots.*
15 years	2.3	24	710	0	1
20 years	3.4	33	1,020	4	3
25 years	4.5	41	1,340	27	1
30 years	5.6	48	1,700	46	1
35 years	6.4	54	2,090	63	2
40 years	7.2	58	2,520	75	....
45 years	7.8	62	2,950	85	....
50 years	8.4	65	3,340	91	1
55 years	8.8	68	3,660	96	1
60 years	9.2	70	3,940	98	4
65 years	9.6	72	4,190	100	4
70 years	10.0	74	4,450	100	2

Birch, paper—Yield per acre—Pure (100 per cent) birch stands.

PENOBSCOT, PISCATAQUIS, SOMERSET, AND FRANKLIN COUNTIES, ME.

[Data gathered by R. L. Marston for Paper Birch Study, 1903-1907.

Age.	Quality II.				
	Average diameter breast-high.	Average. height.	Total yield.	Yield of trees 6 inches and over, in percentage of total yield.	Basis.
	Inches.	*Feet.*	*Cubic feet.*	*Per cent.*	*Sample plots.*
15 years	1.8	21	410	0	1
20 years	2.6	28	580	0	5
25 years	3.4	34	770	18	....
30 years	4.3	40	1,010	35	1
35 years	5.0	45	1,290	50	2
40 years	5.7	49	1,580	63	1
45 years	6.3	53	1,890	73	1
50 years	6.8	56	2,220	82	1
55 years	7.2	59	2,530	89	2
60 years	7.6	61	2,810	94	5
65 years	7.9	64	3,060	97	5
70 years	8.2	66	3,300	100	2

NOTE.—These sample plots were taken in unmanaged stands. All plots with a density less than 50 per cent were discarded. All plots containing less than 40 per cent birch were discarded, and the remainder reduced to 100 per cent birch by dividing the actual birch yield by the percentages of the total basal area formed by the birch. Hence the table applies only to pure birch stands of average density (Quality I, 83 per cent, and Quality II, 75 per cent). For the yield of a mixed stand containing, for example, 60 per cent of birch, a corresponding reduction would be made in the yield. The number of trees per acre was exceedingly irregular and was therefore excluded from the table.

The volume given is total stem volume, though the lowest measurement taken in the sample trees was at 4.5 feet, and this disregard for butt swelling makes the yield conservative.

Gum, blue—Yield per acre—Seedling growth.

CALIFORNIA.

[Data gathered by J. B. Anderson and S. J. Flintham for Eucalyptus Study, 1903 and 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
	Cubic ft.	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
4 years	1,300	1,050	801	800	575	351	350	......	......
6 years	2,600	2,250	1,901	1,900	1,550	1,201	1,200	875	550
8 years	3,700	3,250	2,801	2,800	2,350	1,901	1,900	1,450	1,000
10 years	4,600	4,050	3,501	3,500	2,950	2,401	2,400	1,875	1,350
12 years	5,400	4,775	4,151	4,150	3,500	2,851	2,850	2,200	1,550
14 years	6,150	5,425	4,701	4,700	3,975	3,251	3,250	2,500	1,750
16 years	6,800	6,025	5,251	5,250	4,425	3,601	3,600	2,775	1,950
18 years	7,450	6,650	5,851	5,850	4,900	3,951	3,950	3,025	2,100
20 years	8,150	7,200	6,251	6,250	5,275	4,301	4,300	3,275	2,250
22 years	8,800	7,750	6,701	6,700	5,650	4,601	4,600	3,500	2,400
24 years	9,450	8,325	7,201	7,200	6,050	4,901	4,900	3,700	2,500
26 years	10,050	8,850	7,651	7,650	6,425	5,201	5,200	3,950	2,700
28 years	10,700	9,400	8,101	8,100	6,800	5,501	5,500	4,175	2,850
30 years	11,300	9,925	8,551	8,550	7,175	5,801	5,800	4,400	3,000

Gum, blue—Yield per acre—Seedling growth.

CALIFORNIA.

[Data gathered by J. B. Anderson and S. J. Flintham for Eucalyptus Study, 1903 and 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
	Bd. ft.	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*	*Bd. ft.*
8 years	5,500	4,000	2,501	2,500	......	......	......	......	......
10 years	8,500	6,750	5,001	5,000	3,000	1,001	1,000	......	......
12 years	12,000	9,750	7,501	7,500	5,500	3,501	3,500	......	......
14 years	16,500	13,750	11,001	11,000	8,250	5,501	5,500	......	......
16 years	21,000	17,750	14,501	14,500	11,000	7,501	7,500	4,250	1,000
18 years	26,000	21,750	17,501	17,500	13,750	10,001	10,000	6,000	2,000
20 years	31,000	26,250	21,501	21,500	16,750	12,001	12,000	7,250	2,500
22 years	36,000	30,500	25,001	25,000	19,500	14,001	14,000	8,750	3,500
24 years	41,500	35,250	29,001	29,000	22,750	16,501	16,500	10,250	4,000
26 years	46,500	39,500	32,501	32,500	25,500	18,501	18,500	11,750	5,000
28 years	52,000	44,000	36,001	36,300	28,250	20,501	20,500	13,000	5,500
30 years	57,000	48,500	40,001	40,000	31,500	23,001	23,000	14,750	6,500

Gum, blue—Yield per acre—Sprout growth.

CALIFORNIA.

[Data gathered by J. B. Anderson and S. J. Flintham for Eucalyptus Study, 1903 and 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
	Cu. ft.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*
2 years	820	700	561	560	440	301	300	180	60
3 years	2,100	1,815	1,531	1,530	1,150	771	770	440	110
4 years	3,300	2,760	2,221	2,220	1,715	1,211	1,210	710	210
5 years	4,200	3,555	2,911	2,910	2,265	1,621	1,620	975	330
6 years	5,000	4,250	3,501	3,500	2,740	1,961	1,960	1,220	480
7 years	5,650	4,825	4,001	4,000	3,145	2,291	2,290	1,445	600
8 years	6,230	5,320	4,411	4,410	3,495	2,561	2,560	1,650	740
9 years	6,780	5,790	4,801	4,800	3,810	2,821	2,820	1,825	850
10 years	7,250	6,200	5,151	5,150	4,110	3,071	3,070	2,015	960
11 years	7,700	6,580	5,461	5,460	4,375	3,291	3,290	2,180	1,070
12 years	8,100	6,925	5,751	5,750	4,615	3,481	3,480	2,320	1,160
13 years	8,480	7,250	6,021	6,020	4,825	3,651	3,650	2,445	1,240
14 years	8,820	7,560	6,301	6,300	5,055	3,811	3,810	2,560	1,310
15 years	9,160	7,865	6,571	6,570	5,270	3,971	3,970	2,670	1,370
16 years	9,500	8,150	6,801	6,800	5,450	4,101	4,100	2,700	1,420

Gum, blue—Yield per acre—Sprout growth.

CALIFORNIA.

[Data gathered by J. B. Anderson and S. J. Flintham for Eucalyptus Study, 1903 and 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.
	B. ft.	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*	*B. ft.*
3 years	500								
4 years	2,000								
5 years	4,000	2,750	1,501	1,500					
6 years	6,500	5,500	4,501	4,500	2,750	1,001	1,000		
7 years	11,500	9,500	7,501	7,500	5,500	3,501	3,500		
8 years	16,500	13,750	11,001	11,000	8,500	6,001	6,000	3,250	500
9 years	21,000	17,500	14,001	14,000	11,000	8,001	8,000	5,250	2,500

Hardwoods (second growth)—Yield per acre.

STEWART AND DECATUR COUNTIES, TENN.

[Data gathered by R. Zon for Circular 118—Management of Second Growth in the Southern Appalachians. 1907.]

Age.	Average trees per acre.	Stem volume.		Lumber (Doyle-Scribner).		Ties.	
		Ridge.	Slope.	Ridge.	Slope.	Ridge.	Slope.
	Number.	*Cubic ft.*	*Cubic ft.*	*Board ft.*	*Board ft.*	*Number.*	*Number.*
10 years	1,340	740	500				
20 years	900	1,355	1,200				
30 years	700	1,715	1,700	220	330		
40 years	500	1,945	2,015	600	885		
50 years	355	2,105	2,215	1,520	1,795		
60 years	255	2,200	2,340	2,780	3,200	200	213
70 years	180		2,440				222
80 years	140						

Pine, loblolly—Yield per acre.[a]

MARYLAND.

[Data gathered by W. D. Sterrett for Loblolly Pine Study, 1907.]

Age.	Quality I.							
	Trees per acre.		Average diameter of dominant trees.	Average height of dominant trees.	Yield.		Basis	
	Dominant.	Total.			Total.	Box boards[b]	Plots.	Age.
	Number.	*Number.*	*Inches.*	*Feet.*	*Cu. ft.*	*Bd. ft.*	*Number.*	*Years.*
15 years	800	1,500	4.9	32	2,100	3,400		
20 years	550	840	6.5	43	3,000	9,000	17	12
25 years	400	560	7.8	52	3,650	15,400	15	17
30 years	310	400	8.9	59	4,200	18,900	8	29
35 years	250	320	9.8	65	4,500	21,800	8	40
40 years	200	260	10.6	70	4,750	24,100		

Age	Quality II.							
	Trees per acre.		Average diameter of dominant trees.	Average height of dominant trees.	Yield.		Basis.	
	Dominant.	Total.			Total.	Box boards[b]	Plots.	Age.
	Number.	*Number.*	*Inches.*	*Feet.*	*Cu. ft.*	*Bd. ft.*	*Number.*	*Years.*
15 years	1,040	1,840	3.6	28	1,550	1,400		
20 years	750	1,420	4.9	35	2,100	3,800	6	12
25 years	550	1,000	6.1	41	2,700	7,400	5	21
30 years	400	700	7.2	47	3,100	11,300	8	31
35 years	310	500	8.1	52	3,300	14,000	2	30
40 years	250	370	8.9	57	3,550	15,800	2	48

[a] Approximate yield in pure, unmanaged, fully stocked stands on old fields.

[b] Round or "waney" edged boards—saw cut. Square-edged material would show a smaller yield.

NOTE.—This table is based on sample plots of limited area. Extended areas could hardly be counted on for such a uniformly dense stand unless openings were carefully planted up and the forest kept under scientific control. On the other hand, the natural stands contained about 10 per cent of other species, which are left out of the total as a factor of safety.

The yields were approximated by means of white-pine volume tables, and 10 per cent was deducted from the yield in box boards against a possible variation between the volumes of bark in the two species and as a further factor of safety.

Pine, loblolly—Yield per acre.[a]

MARYLAND.

[Data gathered by W. D. Sterrett for Loblolly Pine Study, 1907.]

Age.	Quality I.		
	Percentage of total yield in diameter classes.		
	1 to 5 inches.	6 to 9 inches.	10 inches and over.
	Per cent.	*Per cent.*	*Per cent.*
15 years	65	34	1
20 years	32	53	15
25 years	13	59	28
30 years	4	56	40
35 years	1	47	52
40 years		34	66

[a] Proportion of total yield in different diameter classes.

Pine, loblolly—Yield per acre—Continued.

MARYLAND—Continued.

Age.	Quality II.		
	Percentage of total yield in diameter classes.		
	1 to 5 inches.	6 to 9 inches.	10 inches and over.
	Per cent.	*Per cent.*	*Per cent.*
15 years	78	22	0
20 years	60	40	0
25 years	39	51	10
30 years	23	57	20
35 years	11	58	31
40 years	5	50	45

Pine, loblolly—Yield per acre—All types combined.

EASTERN TEXAS.

[Data gathered by R. Zon for Loblolly Pine Study, 1903–4.]

Age.	Total.		Within each decade.		Annual average within each decade.	
	Cubic ft.	*Board ft.*[a]	*Cubic ft.*	*Board ft.*[a]	*Cubic ft.*	*Board ft.*[a]
10 years	1,650	....	1,650	....	165	....
20 years	2,600	6,500	950	....	95	....
30 years	3,200	7,450	600	950	60	95
40 years	3,700	9,300	500	1,850	50	185
50 years	4,150	11,900	450	2,600	45	260
60 years	4,600	14,500	450	2,600	45	260
70 years	5,000	17,100	400	2,600	40	260

[a] Herring log rule.

Pine, scrub—Yield per acre.

MONTGOMERY COUNTY, MD.

[Data gathered by W. D. Sterrett for Scrub Pine Study, 1905.]

Age.	Number of trees.	Total stem.	Firewood.	Peeled pulpwood.	Basis.
		Cubic ft.	*Cords.*	*Cords.*	
15 years	2,510	1,280	12.8	....	30 sample plots ¼ to 1 acre each.
20 years	1,470	2,010	20.1	....	
25 years	885	2,510	25.1	....	
30 years	625	2,990	29.9	26.0	
35 years	490	3,450	34.5	30.0	
40 years	420	3,900	39.0	33.9	
45 years	380	4,290	42.9	37.3	
50 years	370	4,650	46.5	40.4	

Pine, white—Yield per acre.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality I.					
	Number of trees.	Basal area.	Mean height.	Volume.	Current annual increment.	Mean annual increment.
		Square ft.	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
25 years	2,430	190	33	3,100	124	124
30 years	1,840	215	41	4,367	253	145
35 years	1,250	230	48	5,850	296	167
40 years	870	238	56	7,083	236	176
45 years	640	243	64	8,000	193	177
50 years	510	246	70	8,767	153	175
55 years	430	249	75	9,475	141	172
60 years	380	252	80	10,100	125	168
65 years	340	255	84	10,633	106	164
70 years	310	258	87	11,100	93	158
75 years	280	261	90	11,567	93	154
80 years	260	263	93	12,000	86	150
85 years	240	266	95	12,383	76	146
90 years	220	268	97	12,767	76	142

Pine, white—Yield per acre.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality II.					
	Number of trees.	Basal area.	Mean height.	Volume.	Current annual increment.	Mean annual increment.
		Square ft.	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
25 years	2,430	163	31	2,700	108	108
30 years	1,840	183	38	3,700	200	123
35 years	1,250	195	45	4,850	230	139
40 years	870	212	52	5,800	190	145
45 years	640	221	59	6,600	160	147
50 years	510	228	65	7,300	140	146
55 years	430	233	71	7,925	125	144
60 years	380	236	76	8,500	115	142
65 years	340	238	80	9,000	100	138
70 years	310	241	84	9,450	90	135
75 years	280	244	87	9,900	90	132
80 years	260	247	89	10,300	80	129
85 years	240	250	91	10,650	70	125
90 years	220	253	93	11,000	70	122

Pine, white—Yield per acre.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality III.					
	Number of trees.	Basal area.	Mean height.	Volume.	Current annual increment.	Mean annual increment.
		Square ft.	*Feet.*	*Cubic ft.*	*Cubic ft.*	*Cubic ft.*
25 years	2,430	150	28	2,300	.....	92
30 years	1,840	165	35	3,033	146	101
35 years	1,250	176	42	3,850	163	110
40 years	870	185	48	4,567	143	114
45 years	640	191	54	5,200	126	116
50 years	510	197	60	5,833	126	116
55 years	430	201	66	6,375	108	116
60 years	380	205	71	6,900	105	115
65 years	340	208	75	7,367	93	113
70 years	310	211	79	7,817	90	112
75 years	280	213	83	8,233	83	110
80 years	260	216	85	8,600	73	107
85 years	240	218	88	8,917	63	105
90 years	220	221	89	9,233	63	103

Pine, white (second growth)—Yield per acre.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality I.	Quality II.	Quality III
	Volume.	Volume.	Volume.
	Board feet.	*Board feet.*	*Board feet.*
20 years	4,600	3,150	1,700
25 years	8,400	5,900	3,450
30 years	15,100	10,800	6,550
35 years	24,950	18,050	11,200
40 years	33,550	25,000	16,450
45 years	40,750	31,450	22,150
50 years	47,450	37,800	27,650
55 years	52,350	42,550	32,750
60 years	57,300	47,400	37,500
65 years	61,850	51,850	41,850
70 years	65,900	55,800	45,700
75 years	69,750	59,500	49,200
80 years	73,300	62,850	52,400
85 years	76,700	66,000	55,300
90 years	80,050	69,000	57,950

NOTE.—Volume in board feet is round-edged box board material.

Pine, white—Yield per acre—Of thinnings.

SOUTHERN NEW HAMPSHIRE.

[Data gathered by L. Margolin for Graded Mill Tallies, 1906.]

Age.	Quality I.			Quality II.			Quality III.		
	Total thinning per acre.		Trees under 5 inches in diameter breast-high.	Total thinning per acre.		Trees under 5 inches in diameter breast-high.	Total thinning per acre.		Trees under 5 inches in diameter breast-high.
	Cubic ft.	*Board ft.*	*Cubic ft.*	*Cubic ft.*	*Board ft.*	*Cubic ft.*	*Cubic ft.*	*Board ft.*	*Cubic ft.*
25 years....	1,350	2,000	830	900	750	750	600	....	600
30 years....	1,730	4,500	660	1,380	3,300	600	1,090	2,200	500
35 years....	1,980	6,800	480	1,680	5,600	450	1,440	4,300	400
40 years....	2,120	8,700	270	1,900	7,500	300	1,640	5,800	300
45 years....	2,240	10,100	60	2,040	8,900	150	1,750	6,900	200
50 years....	2,280	11,200	....	2,100	9,900	....	1,800	7,600	80
55 years....	2,280	12,000	....	2,100	10,400	....	1,780	8,100	....
60 years....	2,260	12,300	....	2,000	10,600	....	1,700	8,300	....
65 years....	2,200	12,300	....	1,850	10,300	....	1,590	8,200	....
70 years....	2,100	11,900	....	1,630	9,500	....	1,420	7,800	....
75 years....	1,950	11,100	....	1,300	8,000	....	1,200	6,900	....
80 years....	1,700	9,500	....	860	5,000	....	920	5,600	....
85 years....	....	....	....	200	1,200	....	650	4,000	....
90 years....	....	....	....	....	....	....	370	2,300	....

NOTE.—Volume in board feet is round-edged box board material.

Poplar, yellow—Yield per acre.

FAIRFAX COUNTY, VA.

[Data gathered by W. W. Ashe for Second Growth Yellow Poplar Study, 1907.]

Age.	Qualities I and II.			Quality I.		Quality II.	
	Number of trees per acre.[a]			Yield.		Yield.	
	Under 5 inches.	5 inches and over.	Total.	Trees 5 inches and over.	Trees 7 inches and over (Scribner).	Trees 5 inches and over.	Trees 7 inches and over (Scribner).
				Cubic feet.	*Board feet.*	*Cubic feet.*	*Board feet.*
10 years....................	930	20	950	50	....	....	....
15 years....................	640	160	800	1,000	500	525	....
20 years....................	310	250	560	2,450	3,000	1,250	1,350
25 years....................	100	285	385	3,425	8,475	2,065	3,250
30 years....................	65	290	355	4,050	11,750	2,750	5,800
35 years....................	55	275	330	4,500	13,750	3,250	8,000
40 years....................	55	255	310	4,875	15,325	3,625	9,650
45 years....................	45	235	280	5,175	16,825	3,900	10,900
50 years....................	35	210	245	5,450	18,300	4,100	11,900

[a] No regular difference could be seen in number of trees per acre between Qualities I and II.

Total tree basal area on best tracts of virgin forest land in different regions.

[Secured from stand tables made by the Forest Service.]

Forest description.	Locality.	Basal area per acre.
		Square ft.
Virgin spruce forest {60 per cent hard woods. 37 per cent spruce.	Adirondacks, N. Y.	136
Virgin spruce forest	Maine	90
Do	do	108
Do	do	111
Virgin spruce forest (44 per cent spruce)	New York	100
Virgin spruce hard wood (25 per cent spruce)	do	100
Virgin spruce swamp (43 per cent spruce)	do	75
Virgin spruce (64 per cent spruce)	New Hampshire	146
Virgin spruce hard wood	do	130
Virgin white pine	Michigan	128
Virgin red pine	do	121
Virgin white pine	Minnesota	200
Average northern forests (75-200 square feet)		120
Second growth hard wood coppice (40 years old)	Pennsylvania	[a] 78
Virgin hard wood	Kentucky	93
Culled hard wood	do	[a] 50
"Barrens" timber	Cecil County, Md	92
"Shore" timber	do	136
"Virgin hard woods"	North Carolina	122
Hemlock hard woods	do	150
Virgin cove hard woods	Tennessee	[b] 133
Average, central hard wood virgin forests (90-150 square feet)		117
Second growth hard wood bottom (60 to 70 years old, 47 per cent red gum).	South Carolina	164
Swamp (cypress, 21 per cent; gum, 72 per cent)	do	113
Longleaf pine (34 per cent) land	do	60
Longleaf pine land	Alabama	63
Longleaf pine land (creek)	do	32
Longleaf pine land	do	53
Loblolly pine land (thicket) (150 years old)	Texas	78
Loblolly pine land (prairie) (over 60 years old)	do	142
Average, southern pine forests (30-120 square feet)		70
Western yellow pine	Arizona	28
Do	do	31
Western yellow pine (50 per cent)	Eastern Washington	55
Lodgepole pine	Montana	130
Lodgepole pine and Engelmann spruce	do	85
Do	do	132
Average, Rocky Mountain forests (30-130 square feet)		80
Douglas fir	Washington	[c] 230
Douglas fir, western yellow pine, and sugar pine	Oregon	188
Western yellow pine, incense cedar, and sugar pine	Madera County, Cal	[d] 227
Do	Butte County, Cal	[d] 242
Western yellow pine and sugar pine	Eldorado County, Cal	215
Do	McCloud, Cal	200
Average, Pacific coast forests (190-240 square feet)		220
Redwood	California	{700 1,000

[a] Not included in average.
[b] 6,000 feet b. m.
[c] 24,000 feet b. m.
[d] Altitude, 4,000 feet.

Total basal area and mean annual increment of normal forests from yield tables for European-managed forests and American-unmanaged forests (sample plots of normal stand).

Species.	Locality.	Quality and remarks.	Age.	Per acre.		
				Trees.	Basal area.	Mean annual increment.
			Years.	*Number.*	*Square ft.*	*Cubic ft.*
Beech	Germany	Quality I	80	269	168	86
Do	do	Quality I	120	157	192	87
Spruce	do	Quality I	80	308	261	165
Do	do	Quality I	120	180	288	132
Scotch pine	do	Quality I	80	218	197	85
Do	do	Quality I	120	154	212	70
Silver fir	do	Quality I	80	325	347	161
White pine	New Hampshire	Quality I	80	260	263	150
		Quality II			247	132
Paper birch	Maine	Quality II. Density 75 per cent.	60	300	94	47
Do	do	Quality I. Density 83 per cent.	60	200	120	65
Loblolly pine	Eastern Texas		40	150	126	93
Yellow poplar (second growth).	Virginia	Quality II	60	165	129	76
Hard woods (second growth).	Southern Appalachians.	Average ridge and slope.	70	180	140	34

METHODS OF INCREASING FOREST PRODUCTIVITY.

By E. E. Carter,
United States Forest Service.

INTRODUCTION.

Proper management of any forest necessitates complete protection from fire, and a market in which wood material of both large and small sizes is salable at a price sufficient to make the practice of intensive forestry profitable. Both of these conditions will prevail in this country in the future. Therefore, they are assumed in this paper.

Productiveness will be treated as the equivalent of growth. In a properly managed forest the cut is equal to the growth or increase in wood material, and therefore for such a forest productiveness means both growth and the amount cut. In our forests the cut exceeds the present growth, or production of wood by the forest, for we are now cutting annually the growth of many past years. In the near future the cut can not increase except as the increase in growth or productiveness of our forests makes it possible.

Increase in both the quantity and the quality of the product of our forests can be secured through proper management. The increase in quantity will result from an increased area of absolute forest land being made producing forest, and from having this area stocked with those species of trees which produce in the shortest time the classes of material desired in this country. The increase in quality will result from managing these stands so that material of desirable size and shape is produced.

QUANTITY OF PRODUCTION.

INCREASED AREA.

PRODUCTION FROM FORESTS NOW VIRGIN OR MATURE.

When settlement began the forests of the United States were not producing forests, nor are the yet uncut and unburned areas producing to-day. There are growing trees in all our mature or virgin forests, but their growth is merely enough to offset loss from natural causes, such as decay, windfall, lightning, and insects. The forest has produced and is now merely keeping the amount of its crop at the point reached years, perhaps centuries, ago. It is forest ready for cutting and can be made producing forest only by cutting in a way that will encourage a new crop to grow.

Ultimately the present virgin or mature forests will be cut over, and the land used either for agricultural crops or for new crops of timber. Under proper management the present condition of unproductiveness will never occur again, for the timber crop on any area kept in forest will be cut as soon as, and usually before, it has stopped increasing. The ideal toward which the forester aims in securing this result may be illustrated by assuming that 100 years are required for a timber crop to become mature; that an area of 100,000 acres is to be handled as one forest, and that each cutting is followed immediately by reproduction. The forest would then be divided into a series of one hundred stands, each of 1,000 acres, differing in age by one year, from the yearling trees up to the century old mature timber. Each year the stand which has reached the century mark would be cut, and the crop from that stand of 1,000 acres would be equivalent to the growth for that year on the whole tract of 100,000 acres. Thus the whole forest would be continuously productive.

In our virgin forests it is as if each stand on reaching the age of 100 years had remained stationary until the whole forest is composed of mature timber. There is no increase in the amount of timber on the ground and consequently no productiveness.

It is unnecessary that this virgin forest be cut clean in order to become productive. The removal of the mature timber will give an opportunity for the younger trees already present to grow to maturity, and thus the area will be made productive. In fact, after the cutting of the mature trees which have overtopped them, the young trees will respond to the increase of light, and, in more dry portions of the country, to the increased soil moisture available for them, and they will make more rapid growth than if the forest had been left untouched. Where clean cutting and the establishment of the new crop by artificial means are practicable, or the cutting of mature timber and the leaving of a sufficient number of young trees to insure a full second crop, the area so cut over becomes once more productive.

There are approximately 188,000,000 acres of mature forest, exclusive of woodland, in the United States, not one acre of which can be classed as producing forest. Some of this land is more valuable for agricultural crops than for growing timber, and will be put under cultivation as soon as cleared. A conservative estimate, however, is that 135,000,000 acres of the present virgin or mature forest are more valuable for growing forest crops than for any other purpose, and will become productive forest land.

PRODUCTION FROM WASTE LANDS.

There is in the United States another class of lands which has no productiveness at present. Worn out agricultural soils, cut and burned areas which are not restocking, and sand dunes, are examples of what are commonly called "waste lands." Experiments have shown that some of these areas need only protection from fire to become productive. Any of them can be artificially stocked with forest trees, and so made productive, for forests can grow on soils too poor for successful agriculture, and, as a rule, should be allowed to grow only on such soils. Also, it is extremely probable that future experiments will show it practicable to grow forests on land too dry, too acid, or too alkaline for farming.

There are 81,000,000 acres of forest land, exclusive of woodland, which have been cut or burned over, but are not restocking. Possibly 10,000,000 acres can be used for agriculture, but additions from worn out agricultural soils, sand dunes, and other sources give a total of at least 90,000,000 acres of waste lands in the United States, all of which can be made productive by artificial stocking with forest trees, or in some cases by merely giving protection from fire.

In making this estimate no consideration has been given to the increasingly large areas of plantations on soils which might be classed as agricultural, but which are devoted to tree production for the sake of windbreaks, or farm woodlots. These are not waste lands, but may be classed with them, for they are areas which are not now, but in the future will be, productive forest. They are, however, not considered, in order to make the estimate of 90,000,000 acres the more conservative.

INCREASED AREA FROM SECURING FULLY STOCKED STANDS.

In the United States it is the exceptional forest, even among those which are now producing, which is fully utilizing the area on which it occurs. Lack of care at the time of lumbering and failure to take steps to secure a fully stocked stand give openings in the forest, some of which are occupied by underbrush.

Many of our forests are naturally somewhat open on account of the inability of certain species to endure the slightest crowding by their neighbors. For example, in an old forest of longleaf pine the crowns of the trees cover hardly more than half of the ground, and yet the stand may be fully stocked in the sense that all the trees of that species which can be produced on the area are already growing on it. It is not such lack of density that is considered here, but rather the failure to have the ground occupied as fully as is possible by the species best adapted to the site conditions.

The examples of this lack of density can be found in every part of the country. On the Pacific coast cut-over areas are frequently stocked with a very scattering stand of trees with a dense cover of chaparral or other brush over most of the ground. This underbrush is not only unproductive, but prevents the forest from becoming more dense, since seedlings are unable to start under its shade or to secure the moisture necessary for their existence in competition with the roots of the brush. In the Rocky Mountain region the yellow-pine forests are almost invariably badly understocked as a result of fire or excessive grazing. In eastern Pennsylvania and other middle Atlantic States there are large areas bearing only a very scattering stand of pitch pine and hard woods, while most of the ground is covered with scrub oak and other worthless underbrush.

There are some exceptions to this lack of density. For instance, there are areas of second growth white pine in New England, second growth Douglas fir in the Northwest, or redwood sprouts in California which are fully stocked. It has been shown, however, that taking averages by forest regions, our second-growth lands have only 30 to 51 per cent of the stand necessary to make a fully stocked forest. It is, therefore, safe to assume that at least 80 per cent of our present producing forest of 225,000,000 acres is stocked with only 50 per cent of the trees which should be growing in it, or that our present growing forest could grow on 145,000,000 acres.

Under proper management all of this land will be fully stocked. The vacancies in our present producing forests are, therefore, equivalent to an area of over 80,000,000 acres. If the 135,000,000 acres of unproductive virgin or mature forest and the 90,000,000 acres of unproductive waste lands are added, the total possible increase in area of productive forests is found to be 305,000,000 acres.

INCREASED GROWTH.

RETENTION OF FAST-GROWING SPECIES ONLY.

Some of our native species are among the fastest growing found in the Temperate Zone. White pine and Douglas fir are being used to a large extent in European forests because their growth equals or exceeds that of any native European species. However, there are about 500 species of trees native to the United States, many of which are very slow growing or fail to attain useful size. The wood of others is of very little use on account of poor mechanical properties. It is certain that under proper management these "weed trees and runts," as Doctor Fernow calls them, will be practically eliminated from our forests. Probably not over 70 species will be purposely retained on account of their value for producing wood material.[a]

In determining what trees shall remain in our forests, one of the chief considerations will be the rate of growth, and this will be considered by stands rather than by individual trees.

If production is considered on the basis of weight rather than volume, for the present, it is obvious that stands of species, which fully utilize the influences which cause tree growth, will have a larger production than those which only partially utilize these same resources. Consequently on any site a species, or mixture of species, which forms a complete cover and thus utilizes the sunlight more completely will have a greater production than a species or mixture which, from the inability of the trees to stand shading, must have open spaces between the trees which allows a portion of the sunlight to reach the ground. For example, a forest of spruce will have a far greater weight production than a forest of paper birch, for the former shades the ground so completely that there is usually no underbrush or grass, and the energy from the sun's heat and light is almost completely utilized by the spruce, while with the paper birch only a portion of the sunlight energy is used by the trees, and the remainder reaches the ground where it enables the cover of grass or brush to exist. In his "Economics of Forestry," page 158, Doctor Fernow says: "The intensity of utilization of the light is the important factor in weight production, and ceteris paribus, in volume production." Other characteristics of trees, such as the ability to extract moisture from relatively dry soils, affect the weight production similarly.

Volume production and weight production are not interchangeable, for the specific gravities of our native woods vary greatly, but there are many opportunities for replacing species which grow very slowly in weight and volume, as a result of incomplete utilization of natural resources, or which do not attain useful sizes and form, with species which will grow more rapidly to usable dimensions and form. For example, there are many areas in the eastern United States at present covered with red cedar, a relatively slow growing tree. The cedar could be replaced nearly everywhere by some faster growing species, such as red oak or tulip poplar for the better soils, and white pine or Norway spruce for the poorer. Another illustration of increased yield both in weight and volume is the replacement of gray birch on worn-out fields and pastures in New England by white pine—a process not infrequently occurring naturally. Still another illustration can be made by considering the replacement of hemlock by growing pure stands of white pine, although hemlock probably utilizes the light resources of any site better than white pine, the wood production is low in volume,[a] and its mechanical properties are such that the wood can be used for no purpose for which the more rapidly growing white pine is not suitable. With both gray birch and hemlock the shape and size of the tree render it less valuable than the white pine.

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[a] Fernow, Econ. of Forestry, p. 169.

This replacement of species by those which grow more rapidly, and the elimination of "weed trees and runts" will be a very long process, and it will be impossible on account of the need for heavy, dense woods to have all of our forests contain only the most rapidly growing species. For example, cottonwood is one of the most rapid growing of our native species, if it is not the leader in volume production. However, white oak, which grows much more slowly in volume but as fast or faster in weight, will be retained on many soils on which cottonwood could grow, because there will always be a demand for wood of the strength and of the mechanical properties which white oak can alone supply.

Furthermore, the wide differences in site conditions in this country will render it necessary to retain some of our relatively slow-growing species, since they are the only ones which can thrive in certain localities. For example, it will probably be impossible to replace our western yellow pine throughout a large part of its range with any faster growing species, for at present no faster growing species is known which will thrive on most sites now occupied by western yellow pine. Similar conditions exist in Europe, as may be shown by quoting from European yield tables for Norway spruce, beech, and Scotch pine on Quality I sites. These show that at 100 years of age the yield of spruce will be 14,248 cubic feet per acre, for beech 8,860 feet per acre, and for Scotch pine 7,760 feet per acre. Although the yield for spruce is nearly double that for Scotch pine, large areas are occupied with the latter species because the site is not suited for growing spruce, but is better suited for Scotch pine than for any other species.

As European foresters have taken some of our species to secure increased growth in their forests, so it will be possible in some instances to increase the yield of our forests by introducing exotics. Norway spruce makes a faster growth than the red spruce of Maine and the Adirondacks, and is now being used in plantations where fire or reckless cutting have made it necessary to replace a spruce stand. The wonderful growth both in weight and volume of eucalyptus in California indicates that this tree is capable of utilizing favorable site factors to a degree far greater than any of our native species, and only its inability to stand frost will prevent its being used to replace our native species over large areas. Unfortunately, its inability to stand low temperatures will result in its being confined almost wholly to areas which are not now forested.

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[a] The specific gravities of white pine and hemlock are, relatively, as 4 to 5.

INCREASED PRODUCTION OF MIXED STANDS.

The differences between species in their ability to endure shade make it possible, in some instances where soil conditions admit, to grow trees of shade-enduring species under or with species which only partially utilize the sunlight. The method is analogous to the growing of agricultural crops under fruit trees in orchards. To make this possible, it is necessary that the intolerant or light-demanding species be started before the trees of shade-enduring species, or that the intolerant species grow much faster in height. Natural examples of this condition are numerous. On the Pacific coast there is almost always a heavy growth of western hemlock and red cedar under stands of Douglas fir. In the Rocky Mountains Engelmann spruce and white fir are frequently found growing under lodgepole pine when the stands of the latter species are no denser than they should be to secure good growth. In the hardwood region beech and maple are frequently found growing under stands of more intolerant species, such as tulip poplar. Throughout the country, pines and spruces are found coming up on old burns under the aspen which first occupied the ground. Under natural conditions this situation is only temporary, since intolerant species can not reproduce under the shade of the more tolerant species, and consequently the stand in time comes to be composed wholly of the more tolerant trees. Under careful management, however, cuttings will be so arranged that the land is kept constantly producing its maximum amount. In many cases of deliberate mixing of light-demanding, rapidly growing species with shade-enduring, slow-growing species at the time a crop is started, or the underplanting of the crop of light-demanding species, after they have grown to some size, with some shade-enduring species will be practiced. The total growth on an area so treated will be greater than if either species were grown pure, and incidentally the quality of the product is frequently much improved and soil conditions maintained. An experiment in Silesia showed that a mixture of spruce and pine produced 18 per cent more than if the spruce were grown in a pure stand on the same site, or 28 per cent more than if pine alone had been grown.[a] Similar results may be expected in this country from mixtures of carefully selected species, with increases in total production, although, as has been noted, there are large areas within our forests on which desirable mixtures are growing already.[b]

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[a] Graves, Forest Mensuration, p. 332.

[b] "Only trees which have a fairly full foliage and preserve a good leaf canopy to an advanced age are fit to be raised in pure woods. Species which do not possess these qualities should be mixed with trees of the former kind." Schlich, vol. 1, p. 197 (3d edition).—15.

INCREASED FERTILITY OF WASTE LANDS AND OPENINGS.

The soil on areas which are covered with forest is constantly improving, largely through the beneficial action of the humus or leaf litter. This action is well known to farmers, especially in the South. Frequently forest growth starts on worn-out fields, grows to maturity, is cut, and the soil on the field found to be sufficiently improved to grow good agricultural crops for a few years. The improvement is the same relatively on soils which are kept under forest continuously. Consequently the producing power of the 90,000,000 acres of waste lands in the United States will improve as successive crops of timber are raised on them. The same is true of many areas of our present producing forests, or even some of our mature and virgin forests, which have in the past been burned and have not been under forest a sufficiently long time to reach their maximum fertility. This gain in producing power is, however, slow and varies greatly with species and localities, consequently no figures for it can be given. It is mentioned merely to emphasize the conservatism of the estimates of the increased productiveness possible in our forests.

POSSIBLE AVERAGE PRODUCTION PER ACRE.

The present growth of fully stocked, growing stands ranges from 30 to 110 cubic feet per acre per annum, with an average of 70 cubic feet for the whole country. The actual production per acre is, however, much less, chiefly owing to the absence of fully stocked stands, and when applied to the small proportion of our forest land which is now productive gives a total annual production of only 6,500,000,000 cubic feet.

The estimated growth per acre of fully stocked stands is already higher than for European countries, for our forests as a whole are in regions extremely favorable for tree growth. As an illustration, it may be stated that on over 75 per cent of our forest area the annual rainfall exceeds 35 inches, and in some localities is over 100 inches. Also, large areas of our forests are already covered with fast-growing species, such as white pine, which, on fair (Quality II) sites, shows a mean annual growth at the age of 60 years of over 140 cubic feet, or double the average for the country.[a]

Any attempt to predict an increase in the growth in cubic feet of fully stocked stands for the country must be purely an estimate. Such an increase is certainly possible, however, and a conservative figure for it is 10 cubic feet per acre, making a total annual production of 80 cubic feet per acre.

TOTAL INCREASE IN QUANTITY POSSIBLE.

The possible increase in growth in cubic feet is equivalent to an annual growth of 80 cubic feet on the 135,000,000 acres of our virgin or mature forests, on the 90,000,000 acres of our waste lands, and on the 80,000,000 acres of land unproductive on account of lack of density in our producing forests. This gives a total of 24,400,000,000 cubic feet. To this must be added an increased growth of 10 cubic feet per acre on

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[a] Present Timber Production, Ziegler, in the report of the conservation commission.

145,000,000 acres (the area on which our present producing forest could be grown), or 1,450,000,000 cubic feet. This makes the total possible increase 25,850,000,000 cubic feet.

QUALITY PRODUCTION.

INCREASED YIELD OF USEFUL MATERIAL.

RETENTION OF NATURALLY WELL-SHAPED AND LARGE GROWING TREES ONLY.

It is not enough that our forests can produce an increased volume of wood. To be truly productive, in the sense of supplying an increased amount of material suitable for use, the wood produced must be of good size and shape. In bringing our forests under proper management not only will slow-growing species be eliminated, but also those which fail to produce stems of a size sufficient to make them capable of use, or of a shape to render possible their use for the objects most desired by the owners of the forests. For example, the redbud of the central hardwood region, although classed as a tree, very rarely attains a size sufficient to make its use possible, and will probably survive only as an ornamental tree in parks and gardens. On the Pacific coast the knobcone pine, even if the poor quality of its wood is disregarded, seldom attains a size sufficient to enable it to be used for saw timber, and consequently it will be especially discriminated against and its reproduction discouraged by foresters. In the Middle West the common catalpa is almost always crooked, and consequently it will be eliminated in time from our forests and replaced, where wood of the same quality is desired, by the straighter growing hardy catalpa. This process of eliminating undesirable species will result in a greater proportion of the total growth of our forests being usable, and will therefore increase the productiveness of our forests.

CONCENTRATION OF GROWTH ON BEST TREES.

Experiments have shown that in a fully stocked stand of any species a definite amount of wood will be grown on a given area each year, or each period of years. Under proper management, the proportion of this growth which will ultimately be used can be greatly increased. If a stand is growing annually at the rate of 80 cubic feet per acre, the proportion of this 80 cubic feet which will ultimately be taken from the forest and used will vary according to whether the wood is placed on stems which have attained or will attain a size suitable for use, or whether it be distributed partly on these stems and partly on trees or branches which will die before reaching a usable size. Therefore, the actual productiveness of the forest can be increased by concentrating as much as possible of the growth on trees which are to remain in the stand until they have attained the most useful size and form.

In this country the benefit of thus concentrating the growth is accentuated by our usual unit of measure of wood products. For practically all saw timber the unit used is the board foot instead of the cubic foot, and timber is sold according to the amount of lumber which can be sawed from the trees. Consequently the larger the tree the greater is the proportion of its actual cubic contents which is paid for and used. It is, therefore, especially desirable to concentrate growth on a relatively small number of trees to force them to large size at the expense of many small trees in the stand.

In the management in fully stocked stands there are always many trees which must soon die from the crowding of their neighbors, consequently their increase in volume is practically wasted. In the meantime they are occupying space and securing light and moisture which could be utilized by the trees which are to remain in the stand, and will be so utilized when the weak trees are finally killed. However, in properly managed stands this process is hastened by the removal of the weak trees, and the growth of the better trees is increased correspondingly. This process is known as thinning.

Examples of the need of thinnings are common in the United States. Lodgepole pine in the Rocky Mountains comes up in exceedingly dense stands on old burns. For a time all the trees grow rapidly, but as soon as the crowns of the trees begin to interlace the struggle for existence begins and natural thinning follows. The growth of the large trees is retarded by the lack of space in which to develop their crowns, and growth in diameter especially soon becomes very slow. The ultimate result in such stands when left to themselves is very frequently that at the age of 150 years there are no trees large enough for saw timber, but many trees of small diameter and good height occupy the ground. If from the start the best trees could have been given an opportunity to develop freely as a result of thinning, there would have been fewer trees to the acre, but these trees would have practically the same volume in cubic contents as the present stand, and would be of sufficient size to furnish a large amount of saw timber. Also, if only fuel wood were desired, a larger proportion of the total cubic contents would be of a size suitable for that purpose.

In this country the demand for saw timber makes the size of the trees on a given area the basis for determining whether the stand is ready for cutting, rather than the total volume of the stand. Since this is so, the concentration of the growth of the comparatively large trees shortens the time required to grow a crop of timber. A crop can be grown, harvested, and a new crop started and grown to some size in the same length of time required for the crop to grow without the aid given by thinnings. For a long period of years, therefore, the productiveness of useful material on any forest area is increased.

Natural thinning is always extremely wasteful, since if the stand is left to thin out itself the trees which die are usually left to rot in the woods. Under proper management this material is utilized and forms from 10 to 50 per cent in volume of the total product of any timber crop.

Throughout the United States it is the exception that more than a small percentage of the material cut from our second growth or producing forests is of sufficient size, shape, and quality to render possible its use as saw timber, ties, poles, or any use other than fuel. The cut of cord wood in this country is approximately 100,000,000 cords a year, the greater portion of which is cut from the forests of the eastern United States. These eastern forests are the ones which have been cut over in the past and are now our productive forests. By far the greater part of our saw timber comes from virgin forests. In cubic measurement the cut of cord wood is greater than that cut for any other purpose. This makes it plain that our producing forests are in reality producing only a very small quantity of saw timber as compared with the fuel wood which they supply.

Proper management by means of thinnings will greatly increase the proportion of large-sized material produced by our forests. Many of our cut-over lands are to-day in practically the same situation as were the forests in parts of Germany at the beginning of the nineteenth century. At that time only 17 per cent of the total amount of timber cut from the forests of Saxony was classed as timber wood. For the period from 1884 to 1893, 79 per cent was timber wood. Similar improvement can be made in our producing forests. At the same time that this increase in the proportion of desirable material was made in Saxony, the annual cut was increased, largely through the use of material removed in thinnings, from 60 cubic feet per acre to 90 cubic feet.

INCREASE IN PROPORTION OF USEFUL MATERIAL POSSIBLE.

If we assume that the total area of our absolute forest land is to be fully stocked with desirable species growing at the rate of 80 cubic feet per annum, the total yield will be 36,000,000,000 cubic feet. Under present conditions, however, an exceedingly conservative estimate would place the proportion of this yield which would be of sufficient size for use as saw timber, ties, poles, or other large-sized products at 25 per cent, or 9,000,000,000 cubic feet. Allowing for waste in logging and milling, this would be equivalent to about 27,000,000,000 board feet. However, by proper care of the forests, the proportion of large-sized material can be raised to at least 50 and possibly to 75 per cent, which would be equivalent to from 54,000,000,000 to 72,000,000,000 board feet per annum; in addition the demand for fuel and other small-sized material would be met by the product of thinnings and the utilization of those parts of the trees which are too small to enable them to be used for saw timber.

SUMMARY.

There are 225,000,000 acres of producing forest in the country. On this area the stand is so open that all the trees could be grown on 145,000,000 acres, which would be producing at the rate of 70 cubic feet per acre annually. By growing only the best species this growth can be increased to 80 cubic feet, an increase of 1,450,000,000 cubic feet.

There is an unutilized area of 80,000,000 acres within our present producing forest. There are 135,000,000 acres of absolute forest land within our virgin or mature forests now unproductive. There are 90,000,000 acres of waste lands which can be made productive by planting or fire protection. All of these areas can be made to produce annually 80 cubic feet per acre, or a total of 24,400,000,000 cubic feet.

The total increase possible in the productiveness of our forests is, therefore, 25,850,000,000 cubic feet.

Only 25 per cent of the yield of our present producing forest is saw timber. It can be made from 50 per cent to 75 per cent saw timber through the concentration of growth on the best trees by thinnings, and the holding of the crop till it reaches good size. This would mean an increase, if all our forest land were productive, from 27,000,000,000 board feet to between 54,000,000,000 and 72,000,000,000 board feet per annum.

FOREIGN SOURCES OF TIMBER SUPPLY.

By Raphael Zon,
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Part I.—THE FOREST RESOURCES OF THE WORLD.

SUMMARY.

The United States ranks second among the nations of the world in the extent of its forests. Russia, including Siberia, has the largest forest area of any country, while Canada ranks third.

The forests of the United States, according to ownership, may be divided roughly as follows:

	Acres.
National forests	100,000,000
State forests	3,000,000
Private and unreserved public forests (unclassified)	442,000,000

The proportion of the forest land owned or controlled by the State is not necessarily an indication of the development of forestry in that State. With only a small percentage of the forest area under its ownership, the Government may exercise great control over the forests of all other owners. Thus, for example, Switzerland, Austria, and France, with only 5 to 12 per cent of the total forests under state ownership, practically manage all the forests within their borders. In the United States there is no national or state supervision over private forests.

The proportion of state-owned forests to total forests in the leading forest countries ranges from 2.2 per cent in Great Britain to 31.9 per cent in Germany, and 84 per cent in Spain. In Germany 66 per cent of the total forest area is under state control.

COMPOSITION.

The coniferous species are of the most value in international trade. Coniferous forests produce a larger percentage of structural timber than hardwood forests. The German tendency is to increase the coniferous producing area at the expense of the hardwood area. To some extent this is also necessary, since hardwoods as a rule require better soil than conifers, and the demands for greater agricultural areas relegate the forests to the poorer soils.

In the United States, as the result of the reckless cutting of coniferous forests and of repeated fires, a conversion into hardwood forests and brush areas is going on. This is particularly true in New England, the Catskills, and the Lake States.

In the following countries hardwoods predominate—Australia and Oceania, British India, Hungary, Croatia and Slavonia, France, Japan, Spain, Portugal, Italy, British Isles, Holland, Denmark. In the following conifers predominate—Russia, Finland, Canada, United States, Sweden, Norway, Germany, Austria, Switzerland.

The United States is the only country which has such a variety of conditions as to favor over large areas the growth of a great number of both conifers and broadleaf species.

ANNUAL GROWTH.

The following table classifies the principal wood-producing countries according to whether they overcut, cut the equivalent of the annual growth, or undercut their forests:

	Annual growth per acre.	Annual cut per acre.
Countries which overcut.	*Cubic feet.*	*Cubic feet.*
Austria	42.4	60 to 67 }53
Hungary	44.4	30 to 33
Croatia-Slavonia	43.4	30 to 32
Canada	20.0	[a] 17
Norway	11.3	
Roumania	[b]	[b]
Spain	[b]	[b]
Portugal	[b]	[b]
Greece	[b]	[b]
Turkey	[b]	[b]
Bulgaria	[b]	[b]
United States	12.0	[a] 42.0
Countries which cut just the annual growth.		
Germany	48.7	48.7
France	37.9	37.9
Switzerland	51.0	51.0
United Kingdom	45.5	45.5
Belgium	58.2?	58.2?
Holland	46.0	46.0
Denmark		
Italy	37.3	37.3
Countries which cut less than the growth.		
Russia	31.0	17.0
Finland	19.8	[c] 13.6
Sweden	25.0	19.1
British India		3.0
Japan		35.0
Servia		

[a] Plus great fire loss (estimated 170).

[b] No definite figures on these countries, but facts indicate that they are being overcut.

[c] 3.44 cubic feet in state forests (38.7 per cent); 20 cubic feet in private forests (61.3 per cent).

In most countries where at present the forests are being overcut, and they are the countries which still contain virgin timber, the proportion of structural timber to firewood in the cut is much greater than will be the case in second growth. This is true because the forests under the present system of cutting do not improve but deteriorate in quality. This holds true not only of the United States, but also of Canada, Austria, and Norway. With countries like Germany and France the percentage of saw-log timber is gradually increasing through proper methods of management.

The cut per acre in such countries as Canada, the United States, and Russia does not represent the actual cut per acre, because the figures do not always refer to the actual productive forest area, but include a great deal of unproductive land, such as swamps, burns, etc. If the figures referred only to the productive forest area, if that could be known, the cut per acre would be much higher.

On the whole, the figures of annual cut and growth show a sad state of affairs. Countries which with proper care for their forest resources could continue to be a source of supply of timber to many other countries deficient in wood are, with few exceptions, overcutting their forest and rapidly deteriorating them, and those few countries with large forest resources which do not overcut do it simply because they either lack capital for opening up their forest or natural means of transportation, as rivers, etc. On the other hand, other countries, though they have not enough forests to supply their own needs, continue to deplete what they have.

ANNUAL CONSUMPTION.

The consumption of wood is different in different countries, being dependent on the industrial development, on the presence of coal for fuel, and on substitutes for structural timber. In the following table are brought together the total annual consumption and the consumption per capita in the various countries of the world:

Country.	Total annual consumption.	Consumption per capita.		
		Total.	Timber.	Firewood.
	Cubic feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
United States	23,000,000,000	260.0	160.0	100.0
Canada	1,111,209,625	192.0	60.0	132.0
Norway	275,000,000	125.0	....	....
Sweden	404,000,000	120.0	....	....
Finland	237,000,000	91.5	....	....
Russian Empire (exclusive of Finland)	6,576,280,000	63.0	25.0	38.0
Austria-Hungary	2,500,000,000	57.0	28.5	28.5
Switzerland	117,000,000	38.0	15.7	22.3
Germany	2,064,122,300	36.6	18.8	17.8
Japan	....	30.0	....	....
France	954,640,000	24.6	6.9	17.7
Denmark	48,826,500	19.8	....	....
Belgium	119,604,126	17.7	10.8	6.9
United Kingdom	670,890,000	14.0	12.8	1.3
Holland	67,200,000	13.1	10.3	2.8
Italy	405,548,000	13.0	2.5	10.5
British India	236,611,600	.8+	....	....

INTRODUCTION.

Under present economic conditions, there is scarcely a civilized country which economically is entirely independent of all other countries. The life of all nations is now closely interwoven; and even countries like the United States or Russia, which contain within their borders practically all natural resources necessary to make them independent in every respect, are constantly interchanging their products with the rest of the world.

It is therefore impossible to form a clear idea of the possibilities of a country and its future development without taking into account the natural resources and the general economic conditions of other countries with which it comes in contact. The highly developed means of transportation makes it often more profitable to obtain certain products from a country which for some reason is best able to produce them than to manufacture them at home, even though it is possible to do so.

A country deprived of certain natural resources may still be prosperous and progressive, because it is able to obtain all that it needs from other countries which have a surplus of the products which it lacks. The British Isles are the most striking example of this. With comparatively limited natural resources and high consumption of timber, grain, and other raw material, England has highly developed industries which enable her to exchange her finished products for the raw materials she needs.[a]

In considering the forest resources of the United States it seems necessary, therefore, to take into account also the forest resources of all other countries in order to determine the extent to which the United States can depend, in case of exhaustion of its own timber, upon the resources of other countries, or to determine the part which it plays and will play in supplying the needs of other countries in forest products.

There is still another reason why it is important in considering the forest resources of the United States to study also the forests and economic conditions of other countries. There is a certain interrelationship between the extent and condition of the natural resources and their use. History clearly shows that in countries with abundant natural resources and sparse population there is no thought of the future, and all energy is directed to the exploitation and reckless use of what nature has abundantly provided. The waste under such conditions is naturally very great and a more economic utilization does not pay. As the population increases and industry grows, the demand for raw material of all kinds increases, and there is a gradual awakening of public opinion to the need of a more careful husbanding of natural resources. Practically all nations have traveled the same road. Some reach this point sooner than others, but every one is inevitably bound to come to the same conclusion. The United States, being younger than European countries and endowed with abundant natural resources, was naturally backward and was until lately lagging somewhat behind. It may therefore be of advantage to this country to seek lessons for our own future guidance in the experience of the older countries which have been benefited by proper care for their forests, waters, and soils.

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[a] This in a general way holds good for forest resources, but with this difference: Forests not only produce timber, but play an important part in the life of every nation by exercising an influence on the water supplies, on agriculture, and the general health of the people. For this reason only a few countries with an insular climate, as England and Holland, may with impunity reduce their forest areas beyond a certain safety limit. Ordinarily a country with a forest area of 20 per cent or less shows to a marked degree bad climatic conditions, with prolonged droughts, frosts, and alternating floods and low water. Portugal with a forest area of only 3½ per cent of the total land area, Spain with 16 per cent, Greece with 13 per cent, Turkey with 20 per cent, Italy with 14 per cent, are good examples of this.

EUROPEAN COUNTRIES.

The forests of Europe occupy an area of 767,500,000 acres, which is about 31 per cent, or not quite one-third, of the total land area of Europe. The most wooded country is Finland, followed by Bosnia and Herzegovina, and Sweden. The least wooded are Portugal and Great Britain.

In accordance with the proportion of forest to total land area, the countries of Europe may be arranged in the following groups:

	Per cent.
Finland	63
Bosnia and Herzegovina	50
Sweden	47.6
Austria and Russia (exclusive of Finland)	30-39
Bulgaria, Servia, Luxemburg, German Empire, Hungary, Norway, Switzerland, and Turkey	20-29
France, Spain, Belgium, Roumania, and Greece	10-19
Netherlands and Denmark	5-9
Portugal and Great Britain	3-4

The proportion of forests decreases from the north and east of Europe toward the south and west. Russia, Finland, Sweden, and Norway together possess 635,000,000 acres of forest, or 76 per cent of the total forest area of Europe. The following table gives the area now under forest, the percentage of forest area, and the forest area per capita, for most of the European countries:

Extent of forests in European countries.

Country.	Total forest area.	Forest area per capita.	Land area under forest.
	Acres.	*Acres.*	*Per cent.*
European Russia	464,610,600	4.3	36.3
Finland	52,500,000	18.75	54.4
	517,110,600		
Austria	23,926,266	.92	32.5
Hungary	18,692,000	1.17	25.7
Croatia and Slavonia	3,760,000	1.64	35.95
Bosnia and Herzegovina	6,380,000	3.90	50.5
	52,837,266		
Sweden	49,300,325	9.7	48.6
Germany	34,989,672	.61	25.89
France	24,021,587	.61	18.5
Norway	16,848,000	7.00	21.00
Spain	(?)16,065,000	.88	13.00
Italy	10,115,404	.31	14.28
Bulgaria	7,602,815	2.4	30.00
Roumania	6,367,000	1.08	18.00
British Isles	3,030,000	.10	4.00
Switzerland	2,140,012	.67	20.6
Greece	2,023,380	.83	(a)
Belgium	1,303,736	.2	17.7
Portugal	1,236,600	.23	5.0
Denmark	628,575	.25	6.3
Holland	617,567	.1	7.7
Servia	3,864,774	1.55	32.0
	750,192,313		

[a] Less than 13 per cent.

NON-EUROPEAN COUNTRIES.

The forests of other countries of the Old and New Worlds, except in a few localities, are little explored, either as to quantity or quality of the timber. In Asia, Russia, British India, and Japan lead in amount of forests. The following table shows the extent of the forest area in the non-European countries in the Old and New Worlds:

Extent of forests in non-European countries.

Country.	Forest area.	Forest area per capita.	Land area under forest.
	Acres.	*Acres.*	*Per cent.*
Asia:			
Asiatic Russia	348,030,000		
India (Schlich)	149,000,000	0.6	24.0
Ceylon	6,762,880		
Japan	57,718,410		
Philippines	49,000,000		
Malay States	101,560		
Straits Settlements	88,320		
Cyprus	448,000		
Australasia:			
British Australasia	126,720,000		6.4
Java	4,920,000		
Hawaiian Islands	1,224,992		
Africa:			
Cape Colony, Natal, Swazeland, and Transvaal	640,502		
Mauritius	87,680		
Madagascar	25,000,000		19.0
Barbary States	9,526,865		
Central Africa	224,000,000		
South America (tropic)	528,000,000		
West Indies	42,668,800		66.6
North America:			
Canada	799,360,000		38.0
Mexico	25,000,000	1.8	5.1
Alaska	107,000,000		
United States	545,000,000		29.0
Total	3,050,298,009		

As may be seen from this table, the non-European countries possess a forest area of over 3,000,000,000 acres. This with the 750,000,000 acres of European forests, form an enormous total of almost 4,000,000,000 acres, or 24 per cent of the total land area of the world. If to this we add the forests of China, Korea, South America, and Africa, for which there are no available data, the extent of the forests of the world will be still greater. Unfortunately, all figures for forest areas are more or less approximations. While the figures for the forests of Austria-Hungary, Germany, France, Sweden, Norway, Finland, Belgium, and Switzerland are fairly accurate, the figures for Russian, Canadian, or even our own forests are only approximate, and will eventually need correction as our knowledge of the forest resources increases. The enormous forest areas in Russia, the United States, and Canada include a large proportion of unproductive land, such as swamps, burns, or lands which sooner or later will be taken up by agriculture, and which do not therefore give a true idea of the forest land proper. The figures, also, showing the percentage of forest land give only an approximate picture of the distribution of forests in the country, because the proportion of forests to total land area greatly varies in different parts of the same country.

Under "forest" is usually understood to mean land covered with woody growth of economic importance. In prehistoric times, after the Glacial Period and also in the early anthropo-historic times, according to traditions and written documents, forests occupied much larger areas than now. However, there are scientists who hold that some forests—in Europe for instance—were preceded by prairie.

The character of the forest depends upon climate. Forests of cold and moderate regions contain fewer species and are more homogeneous in composition than those in tropical regions. True tropical forests are found in some parts of India and in the basins of the large rivers of South America and Africa. In Java, Borneo, Kongo, and along the Amazon and Oronoco the forests are extremely rich in variety of species.

In the world market the wood of common trees has the greatest economic importance. Pine, spruce, larch, and fir are used for construction purposes; while oak, birch, hickory, etc., are used by wood-working industries. The amount of rare precious woods which are used as articles of international trade is comparatively small.

The different countries of the world may be divided into two groups, according as their wood exports exceed their wood imports, or vice versa.

The countries whose wood exports exceed their imports are: Austria-Hungary, Canada, Sweden, Russia, Finland, the United States of America, Norway, Bosnia-Herzegovina, Roumania, and Japan; the countries whose wood imports exceed their exports are: The United Kingdom, Germany, France, Belgium, Spain, Italy, Holland, Denmark, Switzerland, Australian colonies, British possessions in Africa, China, Greece, West Indies, Bulgaria, and Servia.

This investigation can not be as complete as is desirable because data for many countries are entirely lacking. The facts here given are the best that could be obtained.

In determining the forest resources of European countries it was impossible to obtain any figures which would show the total stand in cubic feet or board measure. In most European forests the cutting of timber is confined either to the annual growth or to a fraction of the annual growth and does not take into consideration the forest capital which produces this growth. The Europeans use the annual growth as the criterion of the present stand.

The forest capital itself, or what we call the present stand, is a constant quantity which is not to be disturbed. With improvement of the forest capital (more fully stocked, faster-growing species, etc.), the annual growth increases and more timber is available for annual cutting.

In this country and Canada, where there are still large areas of mature timber and but little forest management in the strict sense of this word, the present stand in cubic feet or board measure is of special interest, as it shows how much virgin timber is available for cutting and how long it will take to exhaust the supply.

In order to make the results obtained for different countries comparable it was attempted in every case to show the forest area, the annual growth, and annual cut, and from these three factors to make deductions as to the forest resources of the different countries. The topics discussed for each country are as follows: Forest area; distribution of the forest throughout the country; composition and character of the forests; annual consumption, cutting, and growth per acre; and wood prices.

FOREST RESOURCES OF VARIOUS COUNTRIES.

AUSTRIA-HUNGARY.

Austria-Hungary is the greatest wood-exporting country in the world. It is not so rich in forests, however, as Sweden, although some provinces in Austria are very well wooded indeed. The combined forest area of Austria, Hungary, and Croatia and Slavonia, exclusive of the Provinces of Bosnia and Herzegovina, is 46,440,000 acres, or 30.24 per cent of the total land area. The forests of Austria proper, however, are very different from those of the Hungarian Kingdom, and it will be better to consider the two separately.

AUSTRIA.

FOREST AREA.

Forestry has developed differently in various parts of Austria. In the northwest Provinces, such as Bohemia, Moravia, and Silesia, where the population is denser than in any other part of the Empire, the forests were early taken care of. Being close to Germany, these northwest provinces have followed Germany in the management of their forests, and some of them were almost model forests even as early as 1848. In the mountainous parts of the country, however, the conditions are not favorable for carrying on rational forest management, and there it is far from being what it should be.

DISTRIBUTION.

The distribution of forests is very uneven, as may be seen from the following table:

Forest area by provinces.

Province.	Area.	Province.	Area.
Danube Provinces:	*Acres.*	Northwest Provinces:	*Acres.*
Upper Austria	1,684,241.1	Bohemia	3,725,190.0
Lower Austria	1,007,729.1	Moravia	1,507,531.5
		Silesia	430,293.6
	2,691,970.2		5,663,015.1
Alpine Provinces:		Northeast Provinces:	
Salzburg	573,088.5	Galicia	4,829,265.9
Tyrol	2,730,722.4	Bukovina	1,106,854.2
Styria	2,654,118.9		
Carinthia	1,120,104.9		
Cariota	1,093,119.3		5,936,120.1
	8,189,154.0	Total	23,996,266.2
Sea Provinces:			
Gorowitz and Istria	570,345.3		
Dalmatia	945,661.5		
	1,516,006.8		

COMPOSITION OF FORESTS.

The forests are composed principally of conifers, such as spruce, pine, and fir. The coniferous forests occupy 16,868,700 acres, while the hardwood forests of seedling origin occupy only 3,522,400 acres. The hardwood forests contain oak, maple, beech, birch, locust, and alder.

CHARACTER OF FORESTS.

The State owns only 10.7 per cent of the forests, or 2,573,000 acres; of this amount, the actual property of the State is only 1,620,000 acres; the rest is bought by the Government with religious funds in its hands and is under its control. Communes own 14.4 per cent of all forests; hereditary and church forests form 13.6 per cent of the forest area, while in the hands of private owners there are 61.3 per cent of the total forest area. Of the latter, 32.4 per cent are in the hands of large owners, and 28.9 per cent in the hands of small owners. The State takes better care of its forests than does any other owner; then come the forests belonging to churches and large owners. The management of communal forests and of those belonging to small owners is poor.

Austria is a good example of the influence of railroads on the exploitation of forests. Thus, before railroads were built in the forested sections of the country, wood was the only fuel, and saw timber was frequently cut for firewood. With the building of railroads, coal was substituted for wood as fuel, and this brought a change in the utilization of the forests. The consumption of firewood by the city of Vienna may be of interest in this connection. Thus, while on an average for the decade 1848–1857, Vienna, then with a much smaller population than now, consumed each year 200,170 cords, of which 77,841 cords were beech wood; for the decade 1888–1897, the annual consumption of wood fell in Vienna to 51,708 cords, of which only 17,563 cords were beech wood. The price of beech firewood during these two periods was $8.76 and $8.01 per cord, respectively, and of softwoods during the same periods was $5.33 and $7.23 per cord, respectively. This decrease in the consumption of firewood and beech wood was due to increase in the consumption of coal and to the fact that beech in the fifties was rarely used for anything but firewood; therefore, the best beech trees were consumed for this purpose. Now, beech finds employment in many uses, and is in great demand in the manufacture of furniture and other products; only the poorest grades are now cut for firewood.

Of the 23,996,266 acres of forest, 20,390,867 acres are managed as high forest, and 3,605,399 acres as coppice and composite forest.

PRESENT STAND AND ANNUAL GROWTH.

The average yearly growth of all the Austrian forests is given as 1,041,234,000 cubic feet, or 42.4 cubic feet per acre. Timber forms 45 per cent of this annual growth. The forests under different management produce different amounts. High forests produce 42.4 cubic feet per acre, of which 45 per cent is timber; composite forests (coppice with standards), 35.3 cubic feet per acre, of which 20 per cent is timber; and coppice, 32.5 cubic feet per acre, of which only 11 per cent is timber. The least growth is in Dalmatia, where of the total forest area only 7.4 per cent is high forest; and the same is true of Gorowitz and Istria, the other sea provinces. In the Tyrol Mountains the forest is scattered and the annual growth is not large, mainly because large areas are devoted to grazing. The total annual growth in the state forests has been estimated lately at 96,767,000 cubic feet. This, divided by the present area of state forests (which is 2,573,100 acres), gives 37.5 cubic feet per acre. There are, of course, districts where the annual growth in the state forests is as high as 70 cubic feet per acre. Assuming an average rotation of 150 years, the present stand must be somewhere in the neighborhood of 156,000,000,000 cubic feet, or close to 1,000,000,000,000 board feet, or an amount equal to about one-half of the remaining standing timber in the United States. The figure of the present stand must be considered as only roughly approximate. It is here given simply to compare the present stand of the Austrian forests with that of the United States.

ANNUAL CUT.

According to the latest figures, the annual cut in the Austrian forests varies from 1,413,000,000 to 1,580,000,000 cubic feet of wood, which amounts to from 60 to 67 cubic feet per acre. Since the average growth per acre is estimated at 42.4 cubic feet, this would indicate that the forests are being overcut.

HOME CONSUMPTION.

In order to determine the home consumption of Austria, the exports must be deducted from the total cut. Since, however, the export figures are not given for Austria proper, but for Austria-Hungary as a whole, only the home consumption of the entire empire can be calculated. This will be given when discussing the forest resources of Hungary.

The consumption of wood grows every year—not for firewood, as previously, but in the form of ties for railroads and timber for the construction of railroad stations, cars, etc. The consumption for railroads alone is estimated to be over 35,000,000 cubic feet each year. The paper and pulp factories now demand constantly increasing amounts of timber.

WOOD PRICES.

In upper and lower Austria, Styria, and Silesia the following prices per cubic foot prevail; the prices are per cubic foot at the place of cutting in the woods, but include the cost of transportation to the point of shipment along the road:

Average price of soft woods (in logs) per cubic foot.

	Cents.
1848	2.35
1870	4.7
1897	6.33

Average price of cord wood per cord.

	1848.	1870.	1897.
Hard woods	$1.90	$3.27	$4.63
Soft woods	1.42	2.42	3.41

In Bohemia and Moravia the following average prices prevail for timber per cubic foot and for firewood per cord:

	1848.	1870.	1897.
Timber:			
Hard woods (in logs)	$0.068	$0.087	$0.115
Soft woods (in logs)	.034	.054	.08
Firewood:			
Hard woods	2.63	4.20	4.91
Soft woods	2.03	3.06	3.98

In Galicia the wood prices per cubic foot were as follows:

	1870.	1897.
Timber:		
Hard woods (in logs)	$0.033	$0.084
Soft woods (in logs)	.028	.109
Firewood:		
Hard woods	1.56	2.92
Soft woods	1.28	4.00

The figures show that the prices of forest products throughout Austria have increased to a great extent in the last fifty years. However, the price of timber has risen much faster than the price of firewood; thus, while timber prices in many localities have trebled, the price of cord wood has only doubled.

In Galicia the prices of saw logs and cord wood have doubled in the twenty-seven years between 1870 and 1897.

HUNGARY.

FOREST AREA AND COMPOSITION.

According to the latest figures available, the forest area of Hungary is 18,692,000 acres. In this is not included the forests of Croatia and Slavonia, which are a part of Hungary. The forests of Croatia and Slavonia include 3,769,000 acres. Since 1885 the forest area of Hungary, with Croatia and Slavonia, has decreased by 54,000 acres. In the northern part (in the Carpathian Mountains) the forests are chiefly hard woods, consisting of beech (1,463,400 acres), oak (1,374,300 acres), pine and spruce (1,776,600 acres), birch (72,900 acres), poplar and willow (27,000 acres), alder, maple, locust (203,000 acres). The hard-wood forests of the Carpathian Mountains are managed as high forest and yield timber of excellent quality.

Hard woods also predominate in the forests of eastern Hungary. The principal species there are beech (5,891,400 acres), spruce and pine (2,421,300 acres), oak (2,772,900 acres), birch (283,500 acres), willow and poplar (64,500 acres), alder, maple, elm, locust, basswood, and larch (70,200 acres).

In the lowlands are found mainly poplar, willow, oak, locust, beech, in all about 580,500 acres. In the forests of the western part, between the rivers Danube and Drave, hardwoods again prevail. Beech occupies 596,700 acres, oak 866,700 acres, spruce and pine

2,800 acres, willow and poplar 89,800 acres, birch, 86,400 acres, all other species, 72,900 acres.

The areas under different species show clearly that Hungary is principally a hard-wood region, while Austria is principally a coniferous region in which conifers form 82 per cent of the total forest.

Of Hungarian forests 1,182,600 acres are proclaimed as protection forests; 272,100 acres are on shifting sand; 16,889,800 acres are on forest land proper, while 4,220,800 acres are on soil which can not be called absolute forest land.

The forests of Croatia and Slavonia, which form the southern part of Hungary, extend between the rivers Drave and Save, and consist chiefly of hard woods. Coniferous forests occupy only 456,300 acres out of 3,779,500 acres of the total forest area.

Following are the areas occupied by the different species for Hungary and Croatia and Slavonia separately and for the Hungarian Kingdom:

Distribution of forests by States and for Kingdom.

Species.	Hungary.	Croatia and Slavonia.	Hungarian Kingdom.
	Acres.	*Acres.*	*Acres.*
Oak forests	5,200,200	828,000	6,029,000
Beech and other hard woods (except oak)	9,247,500	2,484,000	11,758,500
Coniferous forests	4,217,500	456,300	4,673,700
Total			22,461,200

Thus the Kingdom of Hungary has 26.8 per cent of the total forest area under oak, 52.2 per cent under beech and other hard-wood species, 20.8 per cent under conifers, and 0.2 per cent under brush.

The following areas are managed in the Kingdom as high forest: 3,510,000 acres of oak, 8,367,300 acres of other hard woods, 4,649,400 acres of spruce and pine; the rest, 5,934,600 acres, is in composite and coppice forest, of which 25 per cent is simple coppice.

The forests are distributed according to ownership as follows:

Distribution of ownership by States and for Kingdom.

	Hungary.	Croatia and Slavonia.	Hungarian Kingdom.
	Acres.	*Acres.*	*Acres.*
State forest	2,859,000	724,000	3,583,000
Communal forest	3,745,000	394,000	4,139,000
Church forest	1,207,000	92,000	1,299,000
Private and corporation forest	10,922,000	2,570,000	13,492,000

ANNUAL GROWTH AND PRESENT STAND.

Approximate estimates of the annual growth were made in 1882 and 1894; they do not differ essentially. On an average, one acre of forest in Hungary yielded 44.4 cubic feet, and in Croatia and Slavonia 43.4 cubic feet. The annual yield per acre in coniferous forest was estimated at 58.5 cubic feet, that of oak forest 41.5 cubic feet, and all other forest 40 cubic feet. Experience in the State taught that the different species yielded the following sorts of wood:

	Saw logs.	Cord wood and wood for charcoal.
	Per cent.	*Per cent.*
Oak	25 to 40	75 to 60
Beech	3 to 15	97 to 85
Conifers	70 to 85	30 to 15

These figures show that conifers yield the largest percentage of saw timber, and for this reason Hungary with its hard-wood forests could not export large quantities of structural timber, which must be secured chiefly from Austria. The total annual growth is given as 1,000,000,000 cubic feet. At an average annual growth of about 44 cubic feet and an average rotation of one hundred and fifty years the present stand of timber in the Hungarian Kingdom would be represented by 150,000,000,000 cubic feet, or 900,000,000,000 board feet, or an amount equal to a little less than half the remaining virgin timber in the United States.

ANNUAL CUT.

There are no figures available for the total cut in all the forests of Hungary proper. In the state forests the annual cut per acre is 30 to 33 cubic feet per acre, which is less than the annual growth.

ANNUAL CONSUMPTION.

There are no figures for the annual consumption in Hungary alone, so it will be considered together with Austria for the entire Empire.

WOOD PRICES.

Timber brings fairly good prices. Thus oak, the most valuable of all timber trees, is sold in southern Hungary on the stump at 6½ to 11 cents per cubic foot; in Slavonia, at from 11 to 17½ cents per cubic foot. The market prices of saw timber vary from 44 to 55 cents per cubic foot, and sometimes go even as high as 77 cents. Coniferous wood does not command as high prices and is sold at 3.4 to 6.7 cents per cubic foot on the stump, while the finished product in the lumber yard brings as high as from 16½ to 44 cents per cubic foot.

The prices per cubic foot vary according to the species and the kind of wood, as may be seen from the table below:

Prices of timber and cord wood on stump and in yard.

	On stump.	In lumber yard.
LUMBER.	*Cents.*	*Cents.*
Oak	3.8 to 11.2	9.0 to 13.7
Beech	8.7	11.0
Elm and maple	3.7 to 11.2	7.3 to 13.5
Spruce and pine	1.7 to 6.2	3.8 to 8.4
Larch	2.2 to 8.3	5.0 to 10.0
CORD WOOD.		
Oak	$0.60 to $3.20	$2.07 to $4.02
Beech	$1.31 to $2.60	$2.07 to $4.01

In Croatia and Slavonia the stumpage is given as somewhat higher, especially for oak saw logs and oak staves.

BOSNIA AND HERZEGOVINA.

In considering the forest resources of Austria-Hungary one must mention also the two provinces under the control of Austria, Bosnia and Herzegovina.

The forests of Bosnia and Herzegovina occupy 6,380,000 acres, of which 5,016,660 acres are state forests, and the remaining 1,363,500 acres form private property.

In the state forests 3,572,100 acres are high forest and 1,444,500 acres are coppice. The private forests have 351,000 acres of high forest and 1,012,500 acres of coppice.

The annual cut amounts to 7,487,000 cubic feet of coniferous species, 1,413,000 cubic feet of oak, and 9,006,000 cubic feet of beech, besides a large amount of oak bark for tanning. The exploitation of the forests of Bosnia and Herzegovina is just beginning. Twenty years ago they were hardly used at all.

ANNUAL CUT AND CONSUMPTION FOR THE EMPIRE OF AUSTRIA-HUNGARY.

According to the latest data, the annual cut in all of the forests of Austria-Hungary, including Bosnia and Herzegovina, was 2,827,000,000 cubic feet of wood, or 53 cubic feet per acre. Of this cut one-half was sawed into firewood, the other half made into saw logs, at an average price on the stump of 3.5 cents per cubic foot.

The exports for the period between 1895 and 1899 were, on an average, equal to 320,000,000 cubic feet on the stump. Deducting this 320,000,000 cubic feet from the total cut (2,827,000,000 cubic feet), there remains about 2,500,000,000 cubic feet of wood for home consumption. This, with a population of 43,825,000, would give a consumption of 57 cubic feet to each inhabitant. This consumption was distributed roughly somewhat as follows: 530,000,000 cubic feet were sawed into lumber, 40,000,000 cubic feet were used by the railroads, 30,000,000 cubic feet were consumed by pulp and paper mills, and the rest was used by the people as round timber for construction and fuel. These estimates, though crude, give some idea of the consumption.

CANADA.

FOREST AREA.

The forest area of Canada is estimated as 1,249,000 square miles, or 38 per cent of the total land area of Canada. Not all of this, however, is timber land; only about one-third, or 400,000 square miles, may be taken as covered with merchantable timber, the rest being brush land. According to Mr. Stuart a very large portion of the Dominion forest lands is of little value for commercial purposes. According to his estimates, which are the latest and are authoritative, only one-fifth of the 1,406,200 square miles given by him as more or less wooded area, or 280,000 square miles, can be considered as timber land of commercial value. At an average stand of 2,000 feet b. m. per acre this would give about 360,000,000,000 board feet of mature timber.

According to Mr. George Johnson, the statistical officer of the Dominion of Canada, the area of forests in the different provinces is as follows:

Forest area by provinces.

Provinces.	Area of forest in square miles.	Land area under forest.
		Per cent.
Prince Edward Island	800	40
Nova Scotia	6,500	31
New Brunswick	14,800	53
Ontario	102,100	46
Quebec	116,500	51
Manitoba	25,600	40
British Columbia	285,600	75
Territories	697,100	29
Total	1,249,000	[a] 38

[a] Average.

COMPOSITION.

The Canadian forests are stocked with a large number of species, among which the three most important are white pine, found in the southeast part of the Dominion; spruce, occurring over large areas; and Douglas fir, found principally in British Columbia. Besides these there are a large number of others which play a greater or less part in the lumber trade; as, among the hard woods, ash, birch, elm, maple, beech, oak, hickory, etc. The bulk, however, is coniferous timber, as may be inferred from the fact that of the exports 94 per cent are conifers and only 6 per cent hard woods.

The bulk of the forests is found in the eastern and western provinces, the central part of Canada being occupied by large treeless prairies.

The forests of Canada belong chiefly to the provincial governments and to the railroads. In Manitoba and in the Northwestern Territories the forests are the property of the Dominion government and of Indian tribes.

ANNUAL CUT AND CONSUMPTION.

The total annual cut as given by the census of 1891, amounts to 2,045,073,072 cubic feet, distributed among the different products as follows:

	Quantity.	Cubic feet.
Square timber....tons..	865,696	43,294,800
Logs, masts, and spars....pieces..	48,852,225	407,101,875
Staves....M..	92,260	791,128
Railroad ties and fence poles....pieces..	39,048,162	117,144,486
Telegraph poles....do....	303,861	3,282,175
Fire, lath, and pulpwood and bark....cords..	11,439,541	1,464,061,248
Shingles....M..	939,736	9,397,360
Total....		2,045,073,072

The exports were estimated at 613,000,000 cubic feet, which left 1,431,551,150 cubic feet for home consumption. This made a per capita consumption of 296.2 cubic feet. For the last eighteen years the cut has increased enormously. Professor Fernow estimates the present cut at about 2,400,000,000 cubic feet of finished material, which represents not less than 3,000,000,000 cubic feet as it grows in the forest, or about 17 cubic feet per acre. If to this be added the enormous loss of timber through fire, a loss estimated by some to be equal to nearly ten times the amount cut, the drain is at present probably greater than their productive powers; their exploitation is at the expense of the forest capital itself. There are no figures showing the growth per acre, but it is probably at best not more than 20 cubic feet. Schlich[a] gives the total cut of wood for the year 1900, as given in the census report of 1901, as 1,211,209,625 cubic feet, of which 503,527,545 cubic feet were in the form of timber and 707,682,080 cubic feet firewood. This figure, however, can not be the complete returns for the total cut because it is much smaller than the amount given by the census of 1891; the cut since then has increased.

TIMBER PRICES.

The following table conveys an idea of the prices for the different kinds of wood derived from various species, based on the data obtained in the year 1900:

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[a] Forest Policy in the British Empire, Vol. I of his Manual of Forestry.

Quantity and value of timber and firewood in 1900.

Class and kind of wood.	Quantity in solid cubic feet.	Value.	Value per cubic foot.
Square, waney, or flat timber:			
Ash	416,308	$43,331.76	$0.104
Birch	1,203,564	147,044.16	.122
Elm	1,354,765	143,020.08	.105
Maple	346,433	35,990.58	.103
Oak	110,219	19,042.04	.172
Pine	2,381,310	445,389.84	.187
All other kinds	5,914,314	605,074.86	.102
Total or average	11,726,913	1,438,861.32	.122
Logs for lumber, etc.:			
Elm	8,224,100	640,421.36	.077
Hickory	165,000	19,153.26	.116
Hemlock	20,077,800	1,094,680.98	.054
Oak	1,042,100	149,605.38	.143
Pine	153,368,100	14,946,604.66	.098
Spruce	104,067,600	7,140,137.04	.068
All other kinds	78,751,600	4,968,582.12	.063
Total or average	365,696,300	28,950,184.80	.079
Miscellaneous timber:			
Wood for pulp	53,442,720	2,107,791.72	.039
Fence posts	33,357,710	564,420.96	.016
Masts and spars	313,880	28,192.86	.089
Piling	2,402,632	228,585.24	.095
Railroad ties	32,607,160	1,367,421.38	.041
Poles for electric wires	2,040,888	202,499.06	.099
Hop and hoop poles	596,074	....	....
Staves bolts, and headings	1,343,268	23,177.34	.038
Total or average	126,104,332	4,666,081.56	.037
Total of all timber	503,527,545	35,065,327.68	.069
Total of all firewood	707,682,080	14,141,171.16	.01
Grand total of all wood	1,211,209,625	49,206,498.84	.04
Tanbark	....	427,203.72	....
Pot and pearl ashes	....	18,676.98	....
		49,652,379.54	

RUSSIA.

FOREST AREA AND DISTRIBUTION.

The forest resources of Russia are enormous. The total forest area has recently been given as 812,640,600 acres, though, as indicated below, this estimate is unquestionably excessive. The proportion of forest to total land area is 15.45 per cent. The forests are very unevenly distributed, however, as is shown by the following table:

Forest area by provinces.

Provinces.	Forest area.	Proportion of forests to total area.
	Acres.	*Per cent.*
Sixty provinces of European Russia	444,711,600	36.31
Caucasus	19,899,000	17.20
Western Siberia	307,530,000	30.39
Eastern Siberia	40,500,000	5.01
Total	812,640,600	25.73

This table does not include the middle Asiatic provinces, as Transbaikal, Amur, and Sakhalin, which comprise 2,316,000,000 acres, and are practically destitute of forests. The proportion of forest for the provinces which have forests is 25.73 per cent, while the proportion of forest to the total area of the empire, without Finland, is only 15.45 per cent. The table also shows how different is the distribution of forests in various parts of the Russian Empire. Thus, while European Russia has over 36 per cent, the Caucasus has only 17 per cent, and eastern Siberia has but 5 per cent of its area under forest. The forests of European Russia are of course of the greatest value. Even there the distribution is very unequal; the five northern provinces contain practically two-thirds of the total forest area.

COMPOSITION.

The composition of the Russian forests is still very little known. In 1893, out of the 315,900,000 acres of forest in European Russia and Caucasus which were under the administration of the forest department, there was 88 per cent of conifers, 11 per cent of hardwood, and 1 per cent of openings and cuttings which did not come up to forest. In Siberia 71 per cent of the total area was under conifers, 29 per cent under hard woods. Oak occupied 3,284,682 acres, either in the form of pure forests or mixed forests in which oak predominated.

OWNERSHIP.

The State owns 640,188,900 acres, or 87.3 per cent of the total area, and only 172,449,000 acres, or 12.7 per cent, belong to other owners. The distribution of the forests according to ownership, however, varies somewhat in the different regions. Of the 444,711,600 acres in European Russia, more than two-thirds belong to the State and Crown, and only 31 per cent to private owners; in the Caucasus the State owns 13,405,500 acres out of a total area of 19,899,000 acres, or 67.3 per cent; in eastern Siberia the State owns about 76 per cent; in western Siberia the State possesses nearly all of the forests; out of 307,530,000 acres, 303,671,700 acres, or 98.7 per cent, belong to the State. Out of 643,067,100 acres of forest belonging to the State there are, properly speaking, only 341,442,000 acres of true forest land, the rest being either agricultural or swamp land. Therefore the total forest area of Russia should be not 812,640,600, but 510,995,500 acres.

Of the total forest area of European Russia, 1,269,000 acres are declared protective forests and 1,225,800 acres are watershed forests. In a similar way, in the Caucasus 81,000 acres are declared protective and 180,900 acres are watershed forests.

ANNUAL GROWTH AND ANNUAL CUT.

A comparison of the annual growth and annual cut per acre in the Russian forests shows that at present only a fraction of the annual growth is actually used. The reason is that the bulk of the forests is located in regions but poorly developed and with no means of transportation. According to the statement of the Russian administration, only a small part of the annual growth can now be used on account of lack of market. The condition in 1898 was as follows:

1. In the state forests of European Russia, over a forest area of 237,500,000 acres, the annual growth was 13.6 cubic feet per acre, of which only 40 per cent, or 5.1 cubic feet per acre could be actually marketed and used.

2. In the state forests of the Caucasus, with 13,250,000 acres of forest, out of a possible yield of 38.4 cubic feet per acre, only 16 per cent, or 6.2 cubic feet per acre, was actually used.

3. In the state forests of western Siberia, with an area of 95,000,000 acres, out of a possible yield of 3.1 cubic feet per acre only 40 per cent, or 1.3 cubic feet, was actually cut and used.

More wood is used in other forests than in those owned by the State, but these amount to only about one-third of the total forest area. In all forests not under control of the Government the cutting is heavier than in those owned by the State. In the following table are given the cut per acre and the total cut in the different kinds of forest:

Annual cut in cubic feet per acre and total cut by ownership.

	Cut per acre.	Total cut.
State forest	5.15	1,249,994,000
Crown forest	10.75	201,267,000
Communal forest	11.15	98,868,000
Peasant forest	18.50	910,406,000
Private forest	37.04	4,554,990,000
Total		7,015,504,000

Thus the annual cut in European Russia is about 7,000,000,000 cubic feet for the productive forest land (412,000,000 acres), or 17 cubic feet per acre. On the other hand, the total annual growth for the same area is estimated at 12,711,000,000 cubic feet, or about 31 cubic feet per acre. In other words, the cutting in these forests is a little more than one-half of what is produced each year.

In the forests of Asiatic Russia the exploitation is practically nil, hardly amounting to 1.3 cubic feet per acre.

CONSUMPTION.

If from the 7,000,000,000 cubic feet annually cut in the forests of European Russia is deducted the annual export of 423,720,000 cubic feet, the remainder is a home consumption of 6,576,280,000 cubic feet. This, with a population of 104,000,000, gives a per capita consumption of 63 cubic feet. Assuming that one-half of the annual growth (12,711,000,000 cubic feet) is saw-log timber, there is produced annually 6,355,500,000 cubic feet of such material. With a home consumption of about 25 cubic feet of saw logs per capita, the total would be 2,600,000,000 cubic feet, which would still leave 3,755,500,000 cubic feet available for export. At present the wood deficit in all European countries together amounts in logs to about 1,412,000,000 cubic feet per annum. This deficit may become three times as large, and still European Russia could apparently furnish enough timber for the countries which depend on importations for their supply.

WOOD PRICES.

In the yearbooks of the Department of the Treasury for 1898 and 1900 are given stumpage prices. Thus, in 1895, in the remote northern government of Archangels, 1 cubic foot of pine timber on the stump was worth 2.7 cents; in 1898, 3.7 cents; in 1895, spruce was selling for 1.9 cents, and in 1898 for 2.1 cents; pine cord wood was worth on the stump 18 cents per cord. In another northern and remote government, Olonezk, timber on the stump was worth 3.5 cents per cubic foot for pine and 2 cents for spruce. In the government of St. Petersburg the stumpage price was 3.7 cents for pine and 2.2 cents for spruce.

In the central governments the stumpage prices were of course much higher. Thus in the government of Moscow the stumpage price for firewood was given in 1898 as $1.60 per cord for pine wood, $1.21 per cord for spruce, $1.16 per cord for oak, $1.70 per cord for birch wood, and 33 cents for all other species; saw-log timber in the same year was worth 6 cents per cubic foot for pine, 3.7 cents for spruce, 2.5 for all other species. In the government of Petrohovsk firewood was selling for $2.31 per cord for pine on the stump, $2.13 per cord for spruce, $3.23 for oak and birch; saw-log timber was selling for 9.8 cents per cubic foot for pine and spruce and 12.3 cents per cubic foot for oak.

These figures give an idea of the range of prices for timber and firewood in the Russian Empire. Stumpage prices have now reached such a point that further advance is hardly to be expected. There are, of course, many places here and there, remote from means of transportation, where forests are still cheap; but as soon as a railroad is built the price of land, and with it the price of timber, will jump at once.

FINLAND.

FOREST AREA.

Finland, although politically part of the Russian Empire, has had an independent economic development.

The forest area may be given as 52,500,000 acres, or 54.4 per cent of the total land area, and 18¾ acres per capita. The State in all owns or controls 32,117,500 acres, or about 61.2 per cent of all the forest area. The rest, 38.8 per cent, belongs to private owners. The forests extend only to the sixty-ninth degree north latitude. Only a few species, like birch, extend farther north. The forests are composed almost exclusively of pine, spruce, birch, and, to some extent, alder. The most valuable species is, of course, the pine, which is, however, of very slow growth. It takes the pine from eighty to two hundred years to reach sizes suitable for construction, and from one hundred and forty to one hundred and eighty years to make saw logs. The farther north it is, the slower, of course, is its growth. As a rule, the spruce occupies more fertile soil than the pine and reaches its development in a much shorter time.

ANNUAL GROWTH AND CUT.

The cut in the state forests for 1897 amounted to 25,737,000 cubic feet, or 0.74 cubic foot per acre. In the northern forests the cut per acre was only 0.43 cubic foot, while in the rest of the forests there was cut as much as 3.44 cubic feet per acre. Of the total cut, 7,837,000 cubic feet formed cord wood.

In the 20,382,500 acres of private forest there was cut approximately 343,000,000 cubic feet each year, or about 17 cubic feet per acre.

The annual growth per acre for all the forests in the country can be considered as about 19.8 cubic feet per acre. From these figures it can be seen that while in the state forests the cut is considerably below the annual growth, in private forests the annual growth is only a trifle more than the cut.

CONSUMPTION.

The total cut in both private and state forests may be estimated at between 369,000,000 and 379,000,000 cubic feet each year. The exports amounted to about from 132,000,000 to 142,000,000 cubic feet, which, deducted from the total cut, would leave about 237,000,000 cubic feet for home consumption, or 91.5 cubic feet per inhabitant.

WOOD PRICES.

The statistical yearbooks of Finland give the prices of finished sawed lumber. Below are the prices for the period between 1886 and 1897, per cubic foot of sawed boards:

	Cents.		Cents.
1886	9.5	1893	12.8
1887	11.1	1894	12.8
1888	9.7	1895	12.2
1890	14.7	1896	12.6
1891	11.8	1897	13.4
1892	12.6		

SWEDEN.

FOREST AREA.

Up to 1897 Sweden was in the lead of all countries exporting timber. In 1898, however, the exports began to lag behind those from Austria-Hungary, which at that time began to increase enormously.

The lumber industry of Sweden is a comparatively young branch of industry which has grown up in perhaps the last forty years. The country is very rich in forests, but the bulk of them lies in the north, which on account of lack of roads is not easily accessible. It is only with the building of railroads that the present exploitation of the northern forests became possible. The driving of logs in the little streams of the north offers great difficulties, but still these streams are used extensively for this purpose in the same way as are those of Maine and northern New York.

The distribution of forests by provinces, the forest area, and the area per capita are shown by the following table:

Forest area and area per capita by provinces.

	Acres.		Per cent of total area under forest.	Forest area per capita in 1898.
	1890.	1898.		
				Acres.
Stockholm	1,011,752.1	1,012,216.5	54.8	2.214
Upsala	607,871.7	692,298.9	54.7	5.562
Sodermanland	691,909.6	715,022.1	46.1	4.32
Ostergotland	1,526,774.4	1,532,152.8	62.2	5.53
Jonkopings	564,129.9	733,549.5	27.9	3.65
Kronobergs	605,915.1	607,999.5	27.6	3.81
Kalmar	882,754.2	1,389,600.9	51.3	6.08
Gotlands	365,261.4	341,188.2	44.3	6.51
Blekinge	281,358.9	280,978.2	39.3	1.92
Kristianstads	486,939.6	507,338.1	33.0	2.32
Malmobus	143,448.3	152,220.6	13.0	.38
Hallands	169 965.0	187,987.5	15.9	1.32
Goteborgs	285,975.9	288,180.9	23.8	.89
Elfsborgs	1,092,833.1	1,328,445.9	45.5	4.75
Skaraborgs	728,546.4	740,545.2	37.1	3.05
Vermlands	3,455,462.7	3,368,970.9	77.7	1.32
Orebro	1,255,362.3	1,276,605.9	62.3	6.62
Vestmanlands	904,502.7	848,650.5	53.1	6.62
Kopparbergs	4,823,784.9	5,133,777.3	73.8	24.09
Gefleborgs	3,556,583.1	3,694,337.1	81.7	16.01
Vesternorrlands	3,926,545.2	4,374,361.8	73.4	19.28
Jemtlands	4,866,169.5	7,259,992.2	61.8	66.34
Vesterbottens	5,414,569.2	5,696,557.2	41.3	40.64
Norrbottens	6,853,885.2	7,227,338.4	29.4	57.59
Total or average	44,592,260.4	49,390,325.1	48.6	9.7

The proportion of forest to total land area, as can be seen, is enormous, being 48.6 per cent. The forest area per capita of population is given as 9.7 acres. This explains why Sweden is capable of carrying on such a large international trade in forest products with the whole world, sending timber even to Australia, Africa, South America, etc. The forest area diminishes from north to south. Its distribution per capita varies in different provinces, in some being as high as 66 acres and in others less than one-half an acre.

In 1890 the state forests comprised 18,058,000 acres; in 1898 the area had increased to 18,641,000 acres. Of this amount the State actually owned 10,063,000 acres, while the remaining 8,578,000 acres were either the joint property of the State and of institutions or were merely under state control. The forest area which is owned jointly by the State and private individuals amounted to 2,295,000 acres. There are more detailed data for the state forests and those under state control than for any other class.

COMPOSITION.

Conifers occupy 80 per cent of the forest area; north of the line from Christiania to Upsala (60° north lat.) is the coniferous region. Birch, aspen, and mountain ash form the uppermost vegetative limit in the northern alpine region. Spruce (*Picea excelsa*) forms the limit of coniferous growth and borders upon the birch region. Pine (*Pinus silvestris*) grows along the rivers. In the central part, pine and spruce occur in pure stands, while along the coast and toward the south they form mixed stands. Oak and beech, in mixture with conifers, are found in the south.

ANNUAL GROWTH AND CUT.

The following table gives an idea of the cut per acre in the state forests and those under state control, for the period from 1889 to 1898:

Annual cut, in cubic feet, in forests under state control.

Year.	Total cut.	Cut per acre.	Year.	Total cut.	Cut per acre.
1889	44,080,000	4.37	1894	46,196,000	4.15
1890	34,906,000	3.15	1895	46,674,000	4.04
1891	39,143,000	3.55	1896	60,374,000	5.19
1892	42,882,000	3.85	1897	67,117,000	5.74
1893	38,647,000	3.48	1898	75,532,000	6.11

As may be seen from these figures, the amount cut per acre grows every year, and it now reaches an average of 6.11 cubic feet per acre. It must be remembered that the state forests are found chiefly in the north, and that of the 8,578,000 acres of state forests in 1890 there were 3,537,000 acres which were swamp land.

The sale of timber in the state forests is either by annual auction sales or otherwise to supply the needs of the local population in fuel, and a small amount of timber for construction, or the timber is sold by contract; the latter method is practiced chiefly in the two most northern provinces.

The average amount of timber, not counting waste, cut each year in all of the forests may be taken as 954,000,000 cubic feet, or 19.1 cubic feet per acre. The annual cut of wood for 1897 was figured roughly as follows: Export of timber (in logs), 246,863,000 cubic feet; export of finished products (except pulp wood), 3,532,000 cubic feet; wood for pulp and paper, 200,845,000 cubic feet; timber for railroads, 50,114,000 cubic feet; and wood for all other purposes, 559,874,000 cubic feet, making a total of 1,061,228,000 cubic feet.

This figure is larger than the one given above (954,000,000 cubic feet) as the annual cut; the difference is due to the fact that in the latter case the amounts were given in the rough, including waste, which in some cases is very great. In the northern parts, where there are no means of transportation, the part of a tree which can not be utilized is often as high as 40 per cent, almost as much as in the United States. In central and southern Sweden, however, the waste does not exceed 5 per cent.

The average annual growth in all the forests is greater than the annual cut per acre. The annual growth has been estimated at 25 cubic feet per acre; therefore the annual cut could be increased to 1,235,500,000 cubic feet without depleting the forests.

CONSUMPTION.

If we add to the amount of timber exported in the form of logs and lumber the amount of pulp wood also, the total exports would amount to 350,000,000 cubic feet. If we deduct this amount from the total annual cut of 954,000,000 cubic feet, the remainder represents a home consumption of 404,000,000 cubic feet, or 120 cubic feet per capita. If we include also the waste involved in the production of the total annual cut, the per capita consumption would probably be as high as 140 cubic feet. K. von Scherzer[a] estimated the consumption in Sweden (in the eighties) at 101 cubic feet per inhabitant. Mulhull[b] gives the consumption in Sweden and Norway as 92 cubic feet per inhabitant. Since these estimates were made the home consumption in Sweden has increased considerably, and 120 cubic feet per capita may be considered as near the truth.

WOOD PRICES.

Unfortunately there are no recent figures for stumpage prices of timber or wood. The latest available figures are for the year 1890. The following table gives the prices of timber on the stump for the whole tree and by the cubic foot:

Prices of saw-log timber.

District.	Maximum price of saw-log timber.		Minimum price of saw-log timber.	
	Per whole tree.	Per cubic foot.	Per whole tree.	Per cubic foot.
		Cents.		*Cents.*
Norbotten	$0.39	1.6	$0.24.2	0.9
Vesterbotten	1.39		.52.0	
Mellerstra Norrland	1.73 to 1.92		0.39 to .52.0	
Gefle-Dala	1.42 to 1.78		.52 to 1.04	
Bergsland	1.35	5.27	.54.0	
Ostra	1.22 to 1.42		.30 to .52.0	
Vestra		2.9		1.72
Smaland	0.52 to 0.78			

In the district of Sodra the oak wood was sold on an average for 2.57 cents per cubic foot. In the district of Vestra cord wood was sold from the woods at 2.75 to 2.87 cents per cubic foot. In 1892 average auction prices for different kinds of wood were as follows:

Auction prices of timber in 1892.

Districts and provinces.	Timber in the square, per cubic foot.	Sawed timber, per cubic foot.	Timber for construction, per cubic foot.	Cord wood, per cord.
	Cents.	*Cents.*	*Cents.*	
Norbotten	2.2 to 4.4	1.0 to 2.3	0.4 to 1.7	$0.18 to $0.36
Vesterbotten	3.7	1.1 to 3.6		.34 to .45
Mellerstra-Norrland	5.1 to 7.3	2.2 to 7.2	.7 to 3.4	
Gefleborg		2.7 to 8.1		.21 to .93
Kopparberg		2.6 to 4.9		.76
Vermland		2.6 to 3.4		3.58
Orebro	2.6	2.9 to 3.6	2.2 to 3.6	1.77
Vestmanland		2.9		1.47
Upsala	2.2	3.6 to 3.9	2.5 to 4.0	1.10 to 1.83
Stockholm		3.2	2.9	1.96
Ostergotland	2.9	3.7	3.2	
Gotland		3.7	3.2	1.96
Skaraborg	2.6 to 3.6	2.6 to 3.6	2.9 to 3.6	1.40 to 4.57
Kalmar	3.6 to 6.0	1.6 to 4.8	4.0	.37 to 3.08
Jonkoping		1.7 to 2.2	1.7	1.85
Kronoberg		1.5		1.36

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[a] Das wirtschaftliche Leben der Völker, Leipzig, 1885.
[b] Dictionary of Statistics.

The lowest prices for wood were, as would be expected, in the north. In a book[a] published for the Paris Exposition the price of export sawed timber of third quality from 1873 to 1898 was as follows: In 1873, 18.1 cents per cubic foot; in 1874 it was 26.8 cents. After this the price declined, until in 1879 it was only 10.5 cents. In 1883 the price again reached 18.5 cents, in 1897 it was 20.5 cents, and in 1899 it was an even 21 cents per cubic foot. In 1899 and 1900 the price was still high, but in 1901 it fell.

The north of Sweden, the so-called Norrland, is where timber is cut for export. In 1892 the export from Norrland formed 85 per cent of the total export from the Kingdom, and in 1898 was 73 per cent of the total export. With a forest area of 49,390,000 acres, of which probably not less than 10,800,000 acres must be deducted for swamp and is not forest land proper, Sweden has exported on an average for the three years between 1897 and 1899 wood valued at $46,604,500, or at about $1 per acre. Such an export must be considered very large.

The bulk of saw logs is delivered to the harbor by water. There is not a single river in Norrland[b] which is not used for log driving.

One of the greatest scourges in Sweden, as in this country, is forest fires: In 1887, 14,580 acres were thus destroyed, and in 1892, 145,800 acres.

NORWAY.

FOREST AREA.

With a total land area of 124,130 square miles, Norway possesses a forest area of 16,848,000 acres, or 21 per cent of the total land area. The bulk of the forests lies in the northeast, where the proportion of forest is 38 per cent; in the north the forest occupies only 6 per cent of the land area, and in the central part 13 per cent. The forest area per capita is 1.25 acres.

OWNERSHIP.

The state forests comprise 6,807,500 acres, or 28.5 per cent of the forest area. Over one-half of this amount is in the northern provinces of Tromsoe and Finmark, and of this only 1,970,000 acres are really productive forest land. Corporation forests occupy 787,700 acres, or 4.6 per cent; of this, 632,500 acres are productive. Private forests comprise 10,393,250 acres, or 66.9 per cent.

COMPOSITION.

Coniferous forests occupy 75 per cent and hard woods 25 per cent of the total forest area. Among the hard woods beech, elm, and oak, especially the pedunculate oak, predominate. However, the hard woods do not play an important part economically. Beech only forms forests south of Christiania, oak on the southern and eastern coasts up to 63° north latitude, and birch extends beyond the Arctic Circle inland as well as along the coast.

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[a] La Suède, son Peuple et son Industrie.

[b] L. Passarge. Schweden; Fahrt in Nordschweden und Lappland, Berlin, 1897.

The most common of all trees is the pine. It extends beyond the Arctic Circle to 70° north latitude, and forms the most northern forest in existence. It occurs all over the country. Its vertical range is also higher than that of spruce. It ordinarily reaches maturity at 150 years, but in the mountains and in the north at 200 years. The spruce does not extend beyond the Arctic Circle, and occurs on the western coast only scattering or singly. In the South it can be utilized at an age of from 70 to 80 years; in the rest of the country, between 120 and 150 years.

In Norway the growth extends much farther north than in any other country.

ANNUAL CUT, GROWTH, AND CONSUMPTION.

The annual cut is given as 345,000,000 cubic feet, or 20.4 cubic feet per acre. In the forests south of latitude 65° (15 provinces) the annual growth is estimated at 20.5 cubic feet per acre—indeed, in the southwest, at 22.6 cubic feet; west and south of Tondhjem, at 17.9 cubic feet; north of Tondhjem, at 11.3 cubic feet. The actual utilization in this region, however, amounts to 21.5 cubic feet. The convenient access to the western coast, with its deep, sheltered fjords, caused the depletion of the forests in that region. It is estimated that during the last one hundred and fifty years 15,000 acres of private forests have been cleared each year. These figures indicate that the forests of Norway are now being overcut.

One-fifth of the total cut (69,000,000 cubic feet) is exported, and the rest, 276,000,000 cubic feet, remains for home consumption. This, with a population of 2,240,000, gives a consumption of 125 cubic feet per capita.

The peculiarity of the export is that the bulk is in the form of logs and staves and not of sawed lumber. Thus, in 1895 to 1899 the export of sawed lumber formed only 28 per cent of the total. This is in contrast to Sweden, which exports chiefly sawed lumber.

WOOD PRICES.

There are no available statistics regarding wood prices in Norway. They can not, however, be very different from those in Sweden.

The Norwegians realize that at the present cut and export, which in itself amounts to 83 cents per acre, they are cutting not only the annual growth, but the capital itself, and that therefore the forests can not last very long.

BRITISH INDIA.

FOREST AREA.

The total forest area of British East India is not known. The area of state forests under the management of the forest department is nearly 149,000,000 acres. There are extensive areas of private and village forests, but they hardly play an important part in the timber supply of the country. Since the government is owner of all land, except in places where it relinquished its right of ownership to individuals or charitable institutions, the present area of state forests probably includes the greatest part of all forests. The forest area occupies nearly 24 per cent of the total land area, and represents 0.6

of an acre per inhabitant. The state forests are divided into three classes: Permanent state forests (or reserved forests), protected forests, and unclassed forests.

The reserved forest forms only 9.5 per cent of the total land area. In the following table are given the areas of the different classes of government forests in the various provinces:

Government forests, in square miles, under the control of the forest department June 30, 1903.

Provinces.	Total area.	Reserved.	Protected.	Unclassed.	Total.	Per cent of land area under forest.
Bengal	152,453	6,014	3,567	4,033	13,614	8.9
United provinces of Agra and Oudh	105,165	4,048	30	77	4,155	3.9
Punjab	97,223	2,456	4,909	1,914	9,279	9.5
Burma	162,530	20,039	....	103,174	123,213	75.8
Central provinces and Berar	104,170	22,672	....	4	22,676	21.8
Assam	48,961	3,778	....	18,509	22,287	45.5
Coorg	1,582	410	39	121	570	36.0
Northwest frontier province	13,276	234	....	....	234	1.8
Ajmer	2,646	142	....	6	148	5.6
Baluchistan	9,403	208	....	....	208	2.2
Andamans	3,143	156	....	1,795	1,951	62.1
Totals:						
Bengal Presidency	700,552	60,157	8,545	129,633	198,335	28.3
Madras	144,389	17,923	....	1,636	19,559	13.5
Bombay	122,883	13,487	1,320	....	14,807	12.0
	967,824	91,567	9,865	131,269	232,701	24.0
Grand total (acres)	....	58,602,880	6,313,600	84,012,160	148,928,640	....

COMPOSITION.

The composition of the Indian forests is entirely different from that of the United States or Europe. The forests are almost exclusively hardwood, although some are evergreen and some deciduous. The evergreen forests are found mainly along the west coast of the peninsula, in coast districts of Burma and Chittagong, and along the foot and lower slopes of the eastern Himalayas. The deciduous forests are found in the central part of the peninsula and of Burma and contain the most valuable timber trees, such as teak, sâl, sandalwood, red sanders, ironwood, padouk, and others. Conifers (pine, firs, and deodar) are found at the higher elevations in the Himalayas.

ANNUAL CUT AND GROWTH.

The total cut for 1905-6 amounted to 239,250,000 cubic feet, of which 171,500,000 cubic feet was in the form of fuel. Besides this, there were also cut 210,000,000 bamboos. If this cut be divided by the total forest area, the cut per acre would be extremely small, 1.6 cubic feet; this figure does not really represent the true cut, however, because it is referred to an enormous forest area, of which only a comparatively small portion is actually utilized. When the cut is referred to a definite area, the cut per acre is much larger—for example, in Bengal, in the year 1899-1900, from an area of 5,707,800 acres there were obtained 7,340,000 cubic feet of saw timber, 34,566,000 cubic feet of firewood, and 21,000,000 cubic feet of bamboo, or, in all, about 11 cubic feet per acre, and, not counting the bamboo, only about

8 cubic feet per acre. Therefore, to get a better idea of the cut per acre, the total cut should be divided by the area of reserve forests (58,602,800 acres), which would make about 3 cubic feet per acre, not counting bamboo.

There are no figures for the growth per acre. From a study made on sâl, the growth per acre of sâl coppice was estimated to be nearly 30 cubic feet per acre per year. Therefore it is safe to assume that the annual growth in the Indian forests is at present larger than the annual cut.

CONSUMPTION.

The timber exports consist chiefly of teak wood, of which 52,768 tons, or 2,638,400 cubic feet, were exported in the year 1905–6. The exports of all other kinds of wood, principally of bamboo, are insignificant. If this amount be deducted from the total cut and there were no importations, there would be available 236,611,600 cubic feet for a population of nearly 300,000,000 inhabitants, or 0.8 cubic foot per capita. There are, however, some imports of timber from Canada, Sweden, and Austria, which, on an average for the five years between 1895 and 1900, formed one-eighth the value of the total exports. Of course these imports slightly raise the per capita consumption. Still the consumption and cut are very small, and the fact that saw-log timber is needed from other countries indicates the lack of structural timber.

WOOD PRICES.

The chief timber of export is teak, and its price at the point of shipment varies from about 80 to about 85 cents per cubic foot.

ROUMANIA.

FOREST AREA.

The forests of Roumania comprise 6,367,000 acres, of which the State owns 40 per cent, the Crown and communities 8 per cent, and private individuals 52 per cent. The proportion of forest to land is 18 per cent and the area per capita is a trifle over 1 acre (1.08). Of the land classed as state forests (2,712,500 acres), 1,497,000 acres are utilized, 806,250 acres are not utilized, and 407,500 acres are burned.

COMPOSITION.

Thirteen and one-half per cent of the total forest area is occupied by spruce and fir; 20 per cent by beech (also mixed with conifers); 28.3 per cent by beech, oak, and elm in mixture; 31 per cent by pure oak forests; and 7.2 per cent by other hardwood species. The conifers occur chiefly in the Alps and Carpathian Mountains, where their exploitation is very difficult. Only part of the state forests are now being utilized. The insignificant exploitation is due to lack of capital and enterprise. The Government, in order to strengthen the lumber industry, imposed a duty on timber, which increased its price, reduced its importation, and stimulated export. In the future Roumania will undoubtedly play an important part in supplying other countries with timber.

There are no data for the annual growth or consumption. Figures for the annual cut are extremely meager and unreliable.

JAPAN.

FOREST AREA.

The total forest area of Japan, exclusive of Formosa and the Kurile Islands, is 57,718,410 acres, or 59 per cent of the total area. The forests are more extensive in the northern part and are practically confined to the slopes of the mountains which form the backbone of the islands. The greater part of the forests belong to the State. The following gives the distribution of forests according to ownership:

Distribution of forests by ownership.

	Area in acres.
State forests	32,813,300
Crown forests	5,229,472
Municipal forests	4,286,885
Forests of shrines and temples	419,073
Private forests	14,969,680
Total	57,718,410

The state and crown forests are carefully managed, but the private forests are not in such a high state of perfection. In proportion to population, the forest area is quite different in the various provinces; thus in Hokkaido it is 9 acres per capita; in Aomori and Akita, 3¾ acres; in Kochi, 1 acre; in Hiroshima and Kagoshima, three-fourths of an acre; and in Kumamoto only one-half acre. The northern provinces are still rich in virgin forests.

COMPOSITION.

The forests are divided into four zones: 1. Tropical forest; 2. Subtropical forest; 3. Temperate forest; 4. Frigid forest.

1. The tropical forest zone extends over the whole of Formosa, the southern half of the Soochoo Islands, the Yayemaya, and the Ogasawara Islands. The banyan, sieb, and bamboo are the principal growth.

2. The subtropical forest zone comprises a portion of the Soochoo Islands, the whole of Shikoku and Kyushu, and the part of the main island lying south of 36°.

3. The temperate forest zone extends from the northern half of the main island to the southern part of Hokkaido, between 36° and 43° 5′, where the mean annual temperature ranges from 6° to 13° C.

4. The frigid forest zone occupies those parts of the northern half of Hokkaido and the Kuriles, where the average temperature does not exceed 6° C.

On the whole, the composition of the forests is somewhat as follows:

Conifers, 21 per cent; broadleaf forests, 25 per cent; conifers and broadleaf forests, 45 per cent; and sparsely stocked forests, 9 per cent.

In the state forests, the relative proportions of the different kinds of trees is as follows:

Conifers, 11 per cent; broadleaf forests, 28 per cent; mixed conifer and broadleaf forests, 49 per cent; and sparsely stocked forests or openings, 12 per cent.

ANNUAL CUT, GROWTH, AND CONSUMPTION.

The annual cut of timber for three successive years (1900 to 1902) was on an average 2,055,059,400 cubic feet, or about 35 cubic feet per acre. If Japan were not an exporting country, as it is now, at an annual cut of 2,055,159,400 cubic feet and a population of 43,760,000 (exclusive of Formosa), the annual consumption per capita would be 47 cubic feet. As a matter of fact, exports exceed imports, but the exact amount in cubic feet is not available. The actual per capita consumption in Japan must therefore be less than 47 cubic feet, and an estimated consumption of 30 cubic feet must be close to the truth.

There are no figures of annual growth per acre for the whole country. From some working plans prepared for the different state forests it appears that stands of *Cryptomerea japonica* may produce as much as 130 cubic feet per acre per year, and those of *Thujopsis dolabrata* 100 cubic feet per year. From the fact that the Japanese manage to get excellent agricultural crops it may be inferred that they also know how to husband their forest resources and will be able to supply all of the needs of the population and their wonderfully progressive industries.

WOOD PRICES.

Below is given a table of wood prices at Tokyo for the different Japanese woods used in construction, mining, etc.

Prices and uses of various Japanese woods.

TIMBER.

Species.	Price at Tokyo.[a]	Used for—
Chamaecyparis obtusa.......cubic foot..	$0.40	House, ship, and bridge construction.
Cryptomeria japonica............do....	.25	Do.
Picea ajanensis...................do....	.275	House and ship building.
Larix Leptolepis..................do....	.275	Ship and bridge building, telegraph poles, sleepers.
Pinus densiflora..................do....	.15	Piles, etc.
Thuja Sieboldii...................do....	.175 .20	House building, shingles, pulp.
Fraxinus Mandshurica............do....	.25	House and boat building, ties.
Juglans Sieboldina...............do....	.40	Rifle stocks, furniture, carriages.

BOARDS.

Species.	Price at Tokyo.[a]	Used for—
Cryptomeria japonica ..square foot..	$0.15	Valuable furniture and ornaments.
Thuja japonica....................do....	.05	Shingles, cabinets, etc.
Zelkowa keaki.............cubic foot..	.90	Ship, carriage, and house building.
Acer palmatum...................do....	.40	Implements, wagons, etc.
Fagus sylvatica var. Sieboldi....do....	.125	Boats, sleepers, foundations.
Quercus acuta....................do....	.35	Carriages, machines, implements.
Quercus crispula..................do....	.25	Fuel and sleepers.
Cinnamomum camphora..........do....	.55	Boats, cabinets, camphor.
Magnolia hypoleuca..............do....	.35	Small articles.

[a] Original values are given in yen. 1 yen equals about $0.50 United States gold.

THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND.

FOREST AREA.

The forests of the United Kingdom occupy but a small proportion of the total land area. The area of woodlands is estimated at

3,030,000 acres, or 4 per cent of the total land area. The following table gives the proportion of land used for different purposes:

Utilization of the land.

Countries.	Acres of dry land.	Acres under crops and grass.	Acres of forests.	Acres of mountain and heath land.	Acres of other lands.
England	32,390,901	24,679,966	1,665,741	2,324,624	3,710,660
Wales	4,748,466	2,810,824	181,610	1,270,470	485,564
Scotland	19,068,958	4,897,109	878,765	9,289,378	4,003,646
Isle of Man and Jersey	185,453	124,650	869	29,729	30,205
Ireland	19,322,798	15,230,501	303,023	2,226,867	1,562,317
Total	75,706,668	47,743,200	3,030,008	15,141,068	9,792,392
Percentage	100	63	4	20	13

The area under forest per capita is one-tenth of an acre. The area of woodland is smaller than that of any other European country except Denmark. Crown forests comprise only some 67,000 acres, or 2¼ per cent, which is smaller than in any other European state. There are no communal forests. Of the total forest area, 97¾ per cent, or 2,963,000 acres, is in the hands of large private owners.

ANNUAL CUT, CONSUMPTION, AND GROWTH.

The total cut in the United Kingdom for certain periods amounted to: 1855–59, 125,703,600 cubic feet;[a] 1875–79, 131,353,200 cubic feet; and 1895–99, 138,062,100 cubic feet.

Thus the average cut per acre may be accepted as equal to 45.5 cubic feet per year. Assuming that in England only the annual increment is cut, the annual growth would be equal to the total cut. Mulhull estimated that the annual growth per acre is equal to 60 cubic feet, in which case the total annual growth would be 181,800,000 cubic feet. The United Kingdom not only uses all that is cut, but is impelled to import nearly five times that amount.

The total annual consumption and the per capita consumption for a period of years are given in the following table:

Annual and per capita consumption, in cubic feet, for certain periods.

Period.	Produced at home.	Imported.	Total.	Per capita.
1855–59	125,703,600	84,037,800	209,741,400	27.2
1875–79	131,353,200	329,442,300	460,795,500	12.0
1895–99	138,062,100	533,181,000	671,243,100	14.0

Thus the per capita consumption is 14 cubic feet. Half of the total annual cut is firewood; therefore the consumption of timber is 602,212,000, and of firewood is 69,031,000 cubic feet; or the per capita consumption of timber is 12.8 cubic feet, and of fuel is 1.2 cubic feet.

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[a] Berichte über Handlung und Industrie 1900, 598.

WOOD PRICES.

Since the United Kingdom buys nearly half the total export of all the countries of the world, the wood prices in the English market affect practically the whole world. It will, therefore, be of interest to compare the prices for the different kinds of wood imported for a long period of years. The following average annual import prices are borrowed from the Statistical Abstracts for the United Kingdom (1892–1900), covering a period of twenty-four years.

Prices in cents per cubic foot of imported woods.

Year.	Round and hewn logs.			Sawed lumber.	
	Pine and spruce.	Oak.	Teak.	Pine and spruce.	Staves.
1877	22.6	58.8	109.8	....	50.7
1878	19.7	55.6	92.8	....	46.2
1879	17.2	48.7	91.5	....	45.7
1880	19.5	54.4	114.5	....	42.9
1881	19.7	56.4	125.6	....	46.7
1882	20.2	58.2	121.6	25.1	48.9
1883	19.5	57.5	134.4	23.5	42.8
1884	17.4	54.5	137.0	22.1	38.8
1885	16.9	54.1	127.3	21.9	40.8
1886	14.9	53.7	115.1	20.8	38.4
1887	14.0	52.1	98.3	19.8	38.8
1888	15.0	51.1	100.3	21.1	38.7
1889	16.7	54.6	112.8	23.6	38.5
1890	15.4	53.8	106.7	22.2	40.5
1891	14.2	55.6	97.0	20.2	42.8
1892	14.2	55.6	100.9	20.6	41.2
1893	13.2	55.7	97.4	20.2	36.7
1894	12.6	57.0	99.2	20.5	38.7
1895	12.8	54.9	91.4	19.7	38.8
1896	13.4	56.0	100.4	20.8	49.8
1897	13.6	54.3	109.9	22.2	42.4
1898	13.9	53.4	111.2	22.2	43.8
1899	13.7	53.2	114.6	22.8	49.3
1900	14.5	55.9	117.7	26.3	46.9

The lowest price for pine and spruce logs was in 1894. In general, the prices of log timber imported into the United Kingdom were lower in the nineties as compared with the prices that prevailed in the seventies. This may be accounted for by a change in the kind and quantity of logs imported. In the seventies the importations consisted chiefly of large logs, while now the timber imported is generally of smaller size and a great deal of it is for mine timbers and pulp. The prices for logs are comparatively uniform. Teak is used in large quantities for the navy, and its price depends not only on the supply, but also on the demand for it. Lately there has been a great demand for the building of the navy and merchant marine, which has increased the price of teak.

The prices for sawed lumber had fallen greatly by 1895, but since then they have shown a continuous increase. The prices for staves were also low in 1894 and 1895, but lately have shown a tendency to rise.

It is also of interest to compare the prices which different countries have commanded for their timber:

Comparison of selling prices, in cents per cubic foot, of timber in various countries.

	1896.	1897.	1898.	1899.	1900.
Pine and spruce logs from—					
Russia	15.8	16.3	16.9	17.6	18.6
Sweden	13.3	13.8	13.1	14.3	15.7
Norway	13.8	14.3	15.0	15.0	16.6
Germany	20.2	20.8	21.8	24.0	25.2
France	8.1	8.0	8.2	8.2	8.9
United States	28.6	29.2	29.0	32.6	33.2
Canada	55.0	53.0	50.7	54.3	55.0
Pine and spruce sawed timber from—					
Russia	21.9	24.1	24.1	25.0	29.5
Sweden	21.7	23.8	24.0	24.4	27.4
Norway	24.9	27.0	27.1	27.6	28.8
Germany	23.9	25.2	26.3	27.6	35.0
United States	26.4	26.6	26.8	29.2	34.1
Canada	24.4	24.7	24.5	25.1	28.7

The highest prices for hewed as well as unhewed timber were commanded by Canada and the United States, as these countries supplied the largest logs. The timber from Russia contained a great deal of small logs for mines. That from Sweden and Norway was at the lowest prices because it contained very small logs. France ships to England pulpwood only, and such timber is practically on a par with firewood. For sawed lumber, Germany and America commanded the highest prices.

The following tables are of interest as giving details of timber values:

Stumpage prices, in cents per cubic foot, of timber in the south of England, 1904–1905.[a]

	Price.
Prime clean oak, standing	50
Rougher oak	44
Clean-grown ash	60
Beech, 20 inches in diameter and upward	24 to 32
Elm	24
Good clean willow, suitable for cricket bats	60
Hard woods, small dimensions	12 to 18
Larch	24 to 28
Scotch pine and spruce	8 to 16

[a] W. Stone. From Trans. Roy. Scot. Arb. Soc. 1906, pp. 204–5.

Approximate value, in cents per cubic foot, of timber, 1902.[a]

	Under 15 feet.	15 to 25 feet.	25 to 50 feet.	50 feet upward.
Oak	30	40	50	[b] 60
Ash	24	36	[b] 50	....
Elm	12	18	[b] 24	....
Beech	18	24	[b] 36	....
Larch	....	18 to 28	....	....
Scotch pine	....	12 to 18	....	....
Spruce	....	8 to 12	....	....
Spanish chestnut	....	[b] 36	....	....
Horse-chestnut	....	[b] 24	....	....
Walnut (J. regia)	....	[b] 50	....	....
Lime (Tilia sp.)	....	[b] 36	....	....
Hornbeam (C. betulus)	....	[b] 50	....	....
Sycamore (Acer pseudoplatanus?)	....	[b] 36	....	....
Willow	....	[b] 30	....	....
Plane	....	[b] 24	....	....
Poplar, Italian (black)	....	[b] 20	....	....
Poplar, Lombardy	....	[b] 6	....	....
Birch	....	[b] 24	....	....
Maple	....	[b] 18	....	....
Cherry	....	[b] 18	....	....
Acacia	....	[b] 24	....	....
Box	....	[b] 60	....	....
Holly	....	[b] 50	....	....

[a] From Minutes of Evidence, Departmental Committee, British Forestry, 1903, p. 171.

[b] And upward.

GERMANY.

FOREST AREA.

According to the latest figures obtained by the census of 1895, the total area now under forest in Germany is 34,989,672 acres. This forms 25.89 per cent of the total land area. The forest area is 0.63 acre per capita. The distribution of the forests in the different States in the German Empire is given in the following table:

Area of forests of German Empire, 1900.

States.	Total area of forests.	Land area under forest.	Area per capita.
	Acres.	*Per cent.*	*Acres.*
Prussia	20,675,335.0	23.7	0.60
East Prussia	1,611,187.5	17.4	0.80
West Prussia	1,386,620.0	21.7	.88
Brandenburg	3,329,170.0	33.4	1.08
Pomerania	1,547,937.5	20.6	1.00
Posen	1,432,135.0	19.8	.75
Silesia	2,904,732.5	28.8	.60
Saxony	1,339,087.5	21.2	.48
Schleswig-Holstein	315,782.5	6.7	.02
Hanover	1,651,495.0	17.2	.62
Westphalia	1,415,700.0	28.0	.45
Hesse-Nassau	1,556,665.0	39.7	.82
Rhineland	2,087,475.0	30.9	.35
Hohenzollern	97,347.5	34.1	1.45
Bavaria	6,166,382.5	32.5	1.00
Upper Bavaria	1,255,190.0	30.0	.95
Lower Bavaria	841,857.5	31.3	1.25
Pfalz	578,367.5	39.0	.70
Oberpfalz	895,660.0	37.1	1.63
Oberfranken	607,395.0	34.7	1.00
Mittelfranken	630,275.0	33.3	.78
Unterfranken	781,317.5	37.2	1.20
Swabia	576,322.5	23.5	.80
Saxony	961,350.0	25.8	.02
Wurttemberg	1,501,037.5	30.8	.70
Baden	1,419,487.5	37.7	.75
Hesse	600,022.5	31.2	.53
Mecklenburg-Schwerin	591,850.0	18.0	.98
Saxe-Weimar	232,720.0	25.8	.65
Mecklenburg-Strelitz	155,562.5	21.2	1.52
Oldenburg	170,852.5	10.6	.43
Brunswick	273,682.5	30.1	.60
Saxe-Meinigen	259,647.5	42.1	1.25
Saxe-Altenburg	89,757.5	27.1	.45
Saxe-Coburg-Gotha	148,940.0	30.1	.65
Anhalt	144,485.0	25.1	.45
Schwarzburg-Sondershausen	66,777.5	31.0	.83
Schwarzburg-Rudolstadt	103,325.0	43.9	1.10
Waldeck	106,987.5	38.2	1.85
Reuss (Elder-line)	28,132.5	35.6	.40
Reuss (Younger-line)	77,995.0	37.8	.55
Schaumburg-Lippe	17,247.5	20.3	.40
Lippe	83,720.0	27.6	.60
Lubeck	10,207.5	13.7	.10
Bremen	120.0	0.2	....
Hamburg	4,467.0	4.3	....
Alsace-Lorraine	1,099,580.0	30.3	.65
German Empire	34,989,672.5	25.89	.63

Of the total area, the state forests comprise 31.9 per cent, crown forests 1.8 per cent, communal forests 16.1 per cent, institutions and associations own 3.7 per cent, and private owners 46.5 per cent. Below is given a detailed table showing the forest areas according to ownership in the different States and Provinces:

Ownership of forests of German Empire, 1900.

State.	Crown forests.	State and shared forests.	Communal forests.	Institutes forests.	Association forests.	Private forests.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Prussia	181,050.0	6,396,172.5	2,759,115.0	244,930.0	591,072.5	10,502,992.5
East Prussia	....	956,475.0	86,122.5	12,882.5	7,525.0	546,207.5
West Prussia	167.5	829,847.5	59,497.5	3,912.5	3,142.5	480,112.5
Brandenburg	110,862.5	997,242.5	400,967.5	28,622.5	5,857.5	1,785,577.5
Pomerania	21,002.5	483,532.5	135,207.5	16,545.0	1,500.0	890,000.0
Posen	1,880.0	460,652.5	29,575.0	20,612.5	485.0	918,980.0
Silesia	82,780.0	379,660.0	278,610.0	29,200.0	1,900.0	2,223,912.5
Saxony	11,440.0	429,292.5	123,900.0	16,245.0	32,627.5	731,302.5
Schleswig-Holstein	....	90,737.5	23,507.5	4,582.5	512.5	186,142.5
Hanover	....	600,557.5	116,842.5	52,432.5	233,485.0	648,177.5
Westphalia	....	123,495.0	139,255.0	12,582.5	134,357.5	1,006,010.0
Hesse-Nassau	....	652,842.5	532,320.0	31,320.0	103,187.5	236,985.0
Rhineland	....	379,862.5	825,030.0	14,402.5	64,257.5	803,922.5
Hohenzollern	....	....	47,980.0	1,550.0	2,175.0	45,642.5
Bavaria	4,247.5	2,068,592.5	708,885.0	116,202.5	50,037.5	3,138,417.5
Upper Bavaria	170.0	490,920.0	27,147.5	18,375.0	1,007.5	727,570.0
Lower Bavaria	95.0	182,615.0	6,665.0	10,302.5	145.0	662,035.0
Pfalz	62.5	286,017.5	212,955.0	2,692.5	875.0	75,765.0
Oberpfalz	230.0	208,907.5	21,500.0	19,972.5	455.0	554,536.0
Oberfranken	200.0	234,757.5	28,077.5	8,822.5	5,790.0	329,747.5
Mittelfranken	2,060.0	200,222.5	88,005.0	10,972.5	3,412.5	325,602.5
Unterfranken	10.0	250,237.5	296,952.5	20,597.5	27,772.5	196,747.5
Suabia	1,420.0	174,915.0	97,825.5	24,465.0	10,580.0	207,415.0
Saxony	160.0	434,650.0	57,750.0	25,070.0	1,612.5	442,107.5
Wurttemberg	16,205.0	468,790.0	445,487.5	30,317.5	18,387.5	515,850.0
Baden	20,657.5	240,145.0	639,515.0	47,302.5	5,037.5	406,770.0
Hesse	16,621.0	12,302.5	217,375.0	1,690.0	5,565.0	196,875.0
Mecklenburg-Schwerin	19,107.5	248,547.5	56,662.5	29,797.5	....	237,735.0
Saxe-Weimar	125.0	110,597.5	35,562.5	3,027.5	3,212.5	79,286.0
Mecklenburg-Strelitz	3,242.5	102,692.5	12,220.0	545.0	....	36,862.5
Oldenburg	932.5	64,362.5	18,065.0	1,400.0	47.5	86,045.0
Brunswick	....	200,965.0	4,065.0	632.5	44,092.5	23,327.5
Saxe-Meiningen	260.0	110,147.5	60,807.5	1,950.0	22,985.0	63,497.5
Saxe-Altenburg	28,097.5	15,545.0	1,905.0	2,380.0	1,257.5	40,592.5
Saxe-Coburg-Gotha	8,485.0	86,807.5	18,410.0	915.0	8,910.0	25,412.5
Anhalt	49,080.0	50,557.5	2,942.5	1,760.0	207.5	30,937.5
Schwarzburg-Sondershausen	41,872.5	350.0	8,570.0	625.0	7,155.0	8,296.0
Schwarzburg-Rudolstadt	....	875.0	11,560.0	1,170.0	2,122.5	30,597.5
Waldeck	....	887.5	23,007.5	407.5	1,975.0	14,620.0
Reuss (elder line)	10,852.5	....	300.0	690.0	....	16,300.0
Reuss (younger line)	41,250.0	35.0	2,565.0	1,712.5	12.5	22,420.0
Schaumburg-Lippe	16,207.5	....	2.5	10.0	....	1,027.5
Lippe	35,205.5	....	9,142.5	312.5	1,245.0	35,000.0
Lubeck	....	....	12.5	1,362.5	....	1,507.5
Bremen	....	....	....	....	....	120.0
Hamburg	....	....	282.5	22.5	....	1,515.0
Alsace-Lorraine	....	....	491,015.0	6,285.0	....	221,282.5
German Empire	643,255.0	11,149,707.5	5,645,225.0	527,587.5	765,535.0	16,258,412.5

Ownership of forests of German Empire, 1900—Continued.

State.	Crown forests.	State forests.	Communal forests.	Institutes forests.	Association forests.	Private forests.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Prussia	0.9	30.9	13.3	1.2	2.9	50.8
East Prussia	....	59.5	5.3	0.8	0.5	33.9
West Prussia	....	60.6	4.3	0.3	0.2	34.6
Brandenburg	3.3	30.0	12.0	0.9	0.2	53.6
Pomerania	1.4	31.2	8.7	1.1	0.1	57.5
Posen	0.1	32.2	2.1	1.4	....	64.2
Silesia	1.4	13.1	7.9	1.0	0.1	76.5
Saxony	0.4	32.1	9.3	1.2	2.4	54.6
Schleswig-Holstein	....	28.7	10.7	1.4	0.2	59.0
Hanover	....	36.4	7.1	3.2	14.1	39.2
Westphalia	....	8.7	9.8	0.9	9.5	71.1
Hesse-Nassau	....	42.0	34.2	2.0	6.6	15.2
Rhineland	....	18.2	39.5	0.7	3.1	38.5
Hohenzollern	....	....	49.3	1.6	2.2	46.9
Bavaria	0.1	33.8	12.5	1.9	0.8	50.9
Upper Bavaria	....	38.3	2.2	1.4	0.1	58.0
Lower Bavaria	....	19.3	0.8	1.2	....	78.7
Pfalz	....	49.5	36.8	0.4	0.2	13.1
Oberpfalz	....	33.4	2.4	2.2	0.1	61.9
Oberfranken	....	38.6	4.6	1.5	1.0	54.3
Mittelfranken	0.3	31.8	14.0	1.7	0.5	51.7
Unterfranken	....	32.0	36.7	2.6	3.6	25.1
Suabia	0.2	30.4	16.9	4.3	1.8	46.4
Saxony	....	45.2	6.0	2.6	0.2	46.0
Wurttemberg	1.1	31.2	29.7	2.4	1.2	34.4
Baden	1.5	16.9	45.1	3.3	0.3	32.9
Hesse	27.7	2.1	36.2	0.3	0.9	32.8
Mecklenburg-Schwerin	3.2	42.0	9.6	5.0	....	40.2
Saxe-Weimar	....	47.5	15.3	1.7	1.4	34.1
Mecklenburg-Strelitz	2.1	66.0	7.9	0.3	....	23.7
Oldenburg	0.5	37.7	10.6	0.8	....	50.4
Brunswick	....	73.5	1.5	0.2	16.3	8.5
Saxe-Meiningen	0.1	42.4	23.4	0.7	8.9	24.5
Saxe-Altenburg	31.3	17.3	2.1	2.6	1.4	45.3
Saxe-Coburg-Gotha	5.7	58.3	12.4	0.6	6.0	17.0
Anhalt	34.0	41.2	2.1	1.2	0.1	21.4
Schwarzburg-Sondershausen	62.7	0.5	12.8	1.0	10.7	12.3
Schwarzburg-Rudolstadt	....	47.3	11.2	1.1	2.1	38.3
Waldeck	....	62.5	21.5	0.5	1.8	13.7
Reuss (elder line)	38.6	....	1.1	2.4	....	57.9
Reuss (younger line)	52.9	....	3.3	2.2	....	41.6
Schaumburg-Lippe	94.0	....	....	....	....	6.0
Lippe	42.0	3.4	10.9	0.4	1.5	41.8
Lubeck	....	71.8	0.1	13.3	....	14.8
Bremen	....	....	....	....	....	100.0
Hamburg	....	59.3	6.3	0.5	....	33.9
Alsace-Lorraine	....	34.6	44.7	0.6	....	20.1
German Empire	1.8	31.9	16.1	1.5	2.2	46.5

The forest area has changed comparatively little since 1878. In some parts of the Empire there has been a decrease, but in the country as a whole there has been a steady increase. The following table shows the changes mentioned:

Increase, in acres, in forest area of German Empire.

	Total wooded area.	Increase.
1878	34,682,315.0	....
1883	34,770,995.0	88,680.0
1893	34,892,067.5	121,072.5
1900	34,989,670.0	97,602.5
Total	....	307,355.0

The Government has determined the area that may be converted into forests. This potential forest area has been computed at 1,583,000 acres, or 4½ per cent of the present total forest. Of this, 1,362,500 acres are in Prussia alone, which would increase the present forest area by 6.6 per cent. Prussia is doing a great deal in bringing under forest much of its waste land. Thus from 1867 to 1892, 336,582 acres of waste land were bought at $16 per acre to plant to forest, and from 1883 to 1902, 182,782 acres were brought under forest, or an average of 9,140 acres per year. On October 1, 1903, the Prussian forest administration possessed 91,202 acres of waste land, which it intended to plant with trees.

COMPOSITION.

Of the forests, 32½ per cent are covered with hard woods and 67½ per cent with conifers. The constant tendency is to increase the latter at the expense of the former.

The following figures show the progress made in this dirction:

	Hard woods.	Conifers.
	Acres.	*Acres.*
1883	12,006,450	22,704,545
1893	11,668,025	23,207,800
1900	8,802,000	23,627,673

Thus in 1883 the hard woods occupied 34½ per cent instead of 32½ per cent, and the conifers 65½ per cent instead of the present 67½ per cent. The remainder of the forest, comprising 2,699,997 acres, is a mixed composition of hard wood and conifers. In the following table are given detailed figures of the composition of the forest and the areas under different methods of management:

Percentage of forest composition by States.

States and Provinces.	Hard woods.				
	Total.	Coppice.	Composite forest.	Selection forest.	High forest.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Prussia	30.9	7.9	2.6	3.0	17.4
East Prussia	20.3	3.1	1.3	3.4	12.5
West Prussia	11.1	2.0	.5	1.6	7.0
Brandenburg	7.3	1.2	.2	.6	5.3
Pomerania	25.6	3.2	2.4	4.4	15.6
Posen	12.5	2.1	1.5	2.0	6.9
Silesia	12.6	5.1	3.3	1.3	2.9
Saxony	27.9	3.9	5.0	4.1	14.9
Schleswig-Holstein	64.5	6.8	4.9	10.4	42.4
Hanover	36.2	3.6	4.1	3.6	24.9
Westphalia	67.2	22.2	5.1	10.2	29.7
Hesse-Nassau	65.9	8.6	1.1	1.4	54.8
Rhineland	73.5	34.3	4.8	3.5	30.9
Hohenzollern	41.0	1.3	1.0	3.4	35.3
Bavaria	24.6	4.6	7.6	1.2	11.2
Upper Bavaria	7.5	2.0	1.2	4.3	
Lower Bavaria	16.5	1.3	1.1	14.1	
Oberpfalz	3.9	.7	.6	2.6	
Oberfranken	13.5	4.0	3.4	6.1	
Mittelfranken	17.8	3.5	6.4	7.9	
Unterfranken	65.6	11.3	17.7	36.6	
Suabia	25.5	4.5	8.3	12.7	

Percentage of forest composition by States—Continued.

States and Provinces.	Hard woods.				
	Total.	Coppice.	Composite forest.	Selection forest.	High forest.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Saxony	11.3	4.5	3.4	1.3	2.1
Wurttemburg	38.5	.8	12.7	1.9	23.1
Baden	50.3	8.6	10.1	.3	31.3
Hesse	58.4	10.3	.2	.1	47.8
Mecklenburg-Schwerin	36.6	9.0	2.7	1.9	23.0
Mecklenburg-Strelitz	35.8	7.6	4.5	2.1	21.6
Saxe-Weimar	35.4	3.2	9.3	4.3	18.6
Oldenburg	50.9	16.6	.5	....	33.8
Braunschweig	59.4	.5	8.1	1.0	49.8
Saxe-Meinigen	24.8	2.0	10.4	2.2	10.2
Alsace-Lorraine	66.9	6.2	22.8	.5	37.4
German Empire	32.5	6.8	5.0	2.3	18.4
1893	33.5	6.0	5.5	22.0	
1883	34.5	6.5	6.5	21.5	

States and Provinces.	Conifers.						
	Total.	Selection forest.	High forest.	Pine.	Larch.	Spruce.	Fir.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Prussia	69.1	8.5	60.6	57.5	0.1	11.2	0.2
East Prussia	79.7	17.9	61.8	51.0	....	28.4	.4
West Prussia	88.9	8.2	80.7	88.0	....	.8	.1
Brandenburg	92.7	9.7	83.0	92.3	....	.4	....
Pomerania	74.4	11.2	63.2	72.0	....	.2	.1
Posen	87.5	12.0	75.5	86.9	.1	.4	.1
Silesia	87.4	8.1	79.3	71.5	.3	15.2	.4
Saxony	72.1	9.2	62.9	59.8	.1	12.1	.1
Schleswig-Holstein	35.5	5.1	30.4	15.5	.1	19.5	.3
Hanover	63.8	9.4	54.4	46.5	.2	16.9	.2
Westphalia	32.8	7.5	25.3	14.6	.3	17.6	.3
Hesse-Nassau	34.1	.9	33.2	16.6	.2	17.3	....
Rhineland	26.5	2.0	24.5	11.9	.1	14.3	.2
Hohenzollern	59.0	3.5	55.5	8.8	....	40.8	9.4
Bavaria	75.4	8.0	67.4	30.0	.1	40.5	4.8
Upper Bavaria	92.5	....	....	10.3	1.0	81.2	
Lower Bavaria	83.5	....	....	19.2	.7	63.6	
Oberpfalz	96.1	....	....	61.2	.4	34.5	
Oberfranken	86.5	....	....	39.7	.2	46.6	
Mittelfranken	82.2	....	....	53.4	.3	28.5	
Unterfranken	34.4	....	....	25.1	.8	8.5	
Suabia	74.5	....	....	3.5	.4	70.6	
Saxony	88.7	10.0	78.7	30.0	.2	58.1	.4
Wurttemburg	61.5	5.5	56.0	8.6	.1	39.9	12.9
Baden	49.7	3.2	46.5	11.6	.1	25.6	12.4
Hesse	41.6	....	41.6	34.1	.2	7.3	....
Mecklenburg-Schwerin	63.4	2.2	61.2	60.4	.1	2.5	.4
Mecklenburg-Strelitz	64.2	2.5	61.7	63.7	....	.5	....
Saxe-Weimar	64.6	4.7	59.9	39.4	.1	24.8	.3
Oldenburg	49.1	....	49.1	43.9	.2	5.0	....
Braunschweig	40.6	1.6	39.0	7.4	.1	33.1	....
Saxe-Meinigen	75.2	18.0	57.2	27.4	.5	46.8	.4
Alsace-Lorraine	33.1	.5	32.6	11.1	....	2.8	19.2
German Empire	67.5	7.4	60.1	44.6	.1	20.1	2.7
1893	66.5	....	....	41.8	.3	22.5	
1883	65.5	....	....	42.6	.3	22.6	

ANNUAL CUT.

The total cut as given for the year 1899–1900 is 1,706,431,900 cubic feet of timber, or 48.7 cubic feet per acre. The following tables give a clear idea of the annual cut for the whole Empire, as well as for the different States comprising it:

Yield of wood, 1899–1900.

	Actual amount.	Total cut.	Amount per acre.
	Cubic feet.	*Per cent.*	*Cubic feet.*
Timber (nutzholz) [a]	706,631,729	41.4	20.2
Firewood	630,127,804	36.9	17.9
Total of wood over 2¾ inches diameter (derbholz) [a]	1,336,759,533	78.3	38.1
Stump and fagot wood	369,672,367	21.7	10.6
Total production	1,706,431,900	100.0	48.7

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[a] Derbholz is a general term for all wood over 2¾ inches in diameter at the small end; therefore this term will cover saw logs, mine timber, posts, poles, and also such firewood as exceeds this dimension. Nutzholz applies only to saw-log timber, in distinction from all other kinds of derbholz.

Yield of all German forests, by States, for the year 1899–1900.

States.	Timber.	Per cent of derbholz.	Firewood.	Per cent of derbholz.
	Cubic feet.		*Cubic feet.*	
Prussia	341,033,000	53.5	296,308,000	46.5
Bavaria	153,025,000	53.0	135,976,000	47.0
Saxony	36,818,000	75.1	12,214,000	24.9
Wurttemberg	44,972,000	55.1	36,712,000	44.9
Baden	39,889,000	48.0	43,243,000	52.0
Hesse	10,308,000	35.7	18,532,000	64.3
Mecklenburg-Schwerin	9,460,000	33.2	19,062,000	66.8
Saxe-Weimar	5,825,000	55.8	4,624,000	44.2
Mecklenburg-Strelitz	2,365,000	40.8	3,424,000	59.2
Oldenburg	1,447,000	54.7	1,200,000	45.3
Brunswick	7,272,000	49.2	7,519,000	50.8
Saxe-Meiningen	6,883,000	57.3	5,119,000	42.7
Saxe-Altenburg	3,177,000	67.7	1,518,000	32.3
Saxe-Coburg-Gotha	3,636,000	55.4	2,930,000	44.6
Anhalt	3,106,000	52.7	2,789,000	43.7
Schwarzburg-Sondershausen	1,694,000	58.5	1,200,000	41.5
Schwarzburg-Rudolstadt	2,612,000	67.3	1,271,000	32.7
Waldeck	1,024,000	33.7	2,012,000	66.3
Reuss (elder line)	812,000	74.2	282,000	25.8
Reuss (younger line)	3,459,000	82.4	741,000	17.6
Schaumberg-Lippe	494,000	63.6	282,000	36.4
Lippe	1,165,000	36.7	2,012,000	63.3
Lubeck, Bremen, and Hamburg	141,000	26.7	388,000	73.3
Alsace-Lorraine	25,946,000	45.8	30,676,000	54.2
German Empire	706,635,000	52.9	630,140,000	47.1

States.	Total yield of derbholz.	Derbholz per acre.	Stump and fagot wood.	
			Total.	Per acre.
	Cubic feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
Prussia	637,341,000	30.8	225,108,000	10.9
Bavaria	289,001,000	46.9	17,085,000	2.8
Saxony	49,032,000	51.0	16,485,000	16.9
Wurttemberg	81,684,000	54.4	21,498,000	14.3
Baden	83,132,000	58.6	22,416,000	15.7
Hesse	28,840,000	48.0	13,449,000	22.5
Mecklenburg-Schwerin	28,522,000	48.1	6,460,000	10.9
Saxe-Weimar	10,449,000	44.9	3,742,000	16.0
Mecklenburg-Strelitz	5,789,000	37.3	741,000	4.8
Oldenburg	2,647,000	15.5	1,447,000	8.5
Brunswick	14,791,000	54.2	4,907,000	17.9
Saxe-Meiningen	12,002,000	46.2	4,306,000	16.7
Saxe-Altenburg	4,695,000	52.2	1,765,000	19.8
Saxe-Coburg-Gotha	6,566,000	44.1	2,436,000	16.2
Anhalt	5,895,000	40.8	2,153,000	14.8
Schwarzburg-Sondershausen	2,894,000	43.3	565,000	8.8
Schwarzburg-Rudolstadt	3,883,000	37.6	1,200,000	11.9
Waldeck	3,036,000	28.4	1,624,000	15.2
Reuss (elder line)	1,094,000	39.0	459,000	15.8
Reuss (younger line)	4,200,000	54.2	1,977,000	25.5
Schaumberg-Lippe	776,000	45.0	459,000	27.0
Lippe	3,177,000	38.0	988,000	11.7
Lubeck, Bremen, and Hamburg	529,000	35.7	459,000	30.5
Alsace-Lorraine	56,622,000	51.5	17,897,000	16.4
German Empire	1,336,775,000	38.1	369,662,000	10.6

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Yield of the German forests according to ownership, 1900.

	Yield per acre.	Derbholz—		Stump and fagot wood per acre.	Yield per acre.	Timber.	Total yield—	
		Timber.	Firewood.				Split and round firewood.	Stump and fagot wood.
	Cubic feet.	*Per cent.*	*Per cent.*	*Cubic feet.*	*Cubic feet.*	*Per cent.*	*Per cent.*	*Per cent.*
Crown forests	46.9	52.0	48.0	16.7	64.5	38.4	35.4	26.2
State and state managed	48.6	57.1	42.9	9.9	58.5	47.4	35.7	16.9
Communal	37.7	43.8	56.2	15.4	53.1	31.1	40.0	28.9
Institution	47.0	51.2	48.8	13.2	60.3	39.9	38.1	22.0
Association	29.1	35.8	64.2	15.4	44.5	23.4	42.0	34.6
Private	31.1	53.1	46.9	8.8	39.8	41.3	36.6	22.1
Entailed or in trust	42.9	55.9	44.1	10.7	53.4	44.7	35.3	20.0
Other private forests	27.7	51.8	48.2	8.3	36.0	39.9	37.1	23.0

The state forests evidently yield the largest per cent of timber.

Contribution of each class of ownership to total wood production of the German Empire.

	Timber.		Firewood.		Total derbholz.		Stump and fagot cited.		Per cent of the total wood area.
	Cubic feet.	Per cent.	Cubic feet.	Per cent.	Cubic feet.	Per cent.	Cubic feet.	Per cent.	
Crown, state, and part state forests	324,689,000	45.9	246,959,000	39.2	571,648,000	42.8	121,079,000	32.8	33.7
Communal and institution	105,794,000	15.0	131,669,000	20.9	237,463,000	17.7	93,616,000	25.3	17.6
Association	7,978,000	1.1	14,332,000	2.3	22,310,000	1.7	11,755,000	3.2	2.2
Private	268,139,000	38.0	237,181,000	37.6	505,320,000	37.8	143,212,000	38.7	46.5
German Empire	706,600,000	100.0	630,141,000	100.0	1,336,741,000	100.0	369,662,000	100.0	100.0

This shows that the state forests, with only 33.7 per cent of the total forest area, produce 43 per cent of the derbholz and 46 per cent of the timber; while the private forests, with 46.5 per cent of the total area, produce only 38 per cent of derbholz and of timber.

Timber yield of the German state forests in percentage of the total wood yield and of the yield of material over 2¾ inches in diameter.

Year.	Prussia.		Bavaria.		Saxony.	Wurttemberg.	Baden.		Alsace-Lorraine.	Brunswick.
	Total yield.	Yield over 2¾ inches.	Total yield.	Yield over 2¾ inches.	Yield over 2¾ inches.	Yield over 2¾ inches.	Total yield.	Yield over 2¾ inches.	Total yield.	Yield over 2¾ inches.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1890	36	47	40	46	80	54	34	42	40	....
1891	36	46	50	55	79	51	32	39	38	....
1892	36	46	50	55	79	54	32	39	54	....
1893	36	47	37	43	78	52	32	39	39	....
1894	44	53	40	46	78	52	33	40	38	....
1895	41	51	42	48	79	53	37	44	41	52
1896	40	50	45	50	79	52	40	47	42	54
1897	43	54	46	51	70	54	41	49	43	55
1898	45	56	44	50	81	56	40	47	47	53
1899	47	60	45	51	81	57	40	48	47	50
1900	48	60	45	52	82	58	40	47	44	52
1901	48	59	42	48	80	57	38	46	39	50
1902	45	55	43	49	79	58	42	50	47	50
1903	....	....	....	....	....	....	....	....	52	....

Yield according to species.—The average yield of derbholz (wood over 2¾ inches in diameter) is greater for conifers than for the broadleaf species. The yield of the State forests in Wurttemberg per acre gives the following result:

Yield of State forests per acre.

Year.	Broadleaf species.			Conifers.		
	Total yield.	Wood over 2¾ inches diameter.	Fagot wood.	Total yield.	Wood over 2¾ inches diameter.	Fagot wood.
	Cubic feet.	*Cubic feet.*	*Per cent.*	*Cubic feet.*	*Cubic feet.*	*Per cent.*
1861-70	....	40.9	....	....	72.0	....
1874-76	59.3	40.9	31	91.8	81.9	11
1882	60.2	40.2	33	84.6	74.0	13
1888	72.6	53.4	27	91.8	79.6	13
1895	71.9	53.1	26	85.7	74.0	15
1900	77.0	59.4	23	91.4	78.5	14
1901	78.9	60.2	24	97.4	82.9	15

Forests in coppice and compound coppice yield less than high forests; e. g., in the state forests of Baden the yield per acre for high forests from 1892 to 1896 was 79.5 cubic feet, and from 1879 to 1901, 91.2 cubic feet; for coppice and compound coppice, from 1892 to 1896, 55.1 cubic feet, and from 1897 to 1901, 65.7 cubic feet.

The German Empire, with an annual production of 48.7 cubic feet per acre, shows the highest wood production of all European countries. Of the different kinds of forests, the state and crown forests produce the greatest amount of wood per acre per year—64½ cubic feet against 39.8 cubic feet in private forests. At the same time the state forests produce the largest percentage of saw-log timber—57.1 per cent against 53.1 per cent in private forests. Of all the States Saxony produces the largest proportion of saw-log timber. The different States may be arranged in the order of their production of saw-log timber as follows:

Distribution of saw-log timber by States.

States.	Per cent.	States.	Per cent.
Saxony	75	Brunswick	49
Saxe-Meiningen	57	Baden	48
Wurttemberg	55	Alsace-Lorraine	46
Prussia	54	Hesse	36
Bavaria	53	Mecklenburg-Schwerin	33

Although Prussia includes 59.1 per cent of the forest area of the Empire, it furnishes only 47.6 per cent of the total production of timber over 2¾ inches, and only 48.3 per cent of the timber production of the Empire; in each case less than half.

Bavaria, Wurttemberg, Baden, Alsace-Lorraine, Hesse, and Saxony, which together include 33.5 per cent of the total forest area, produce 44 per cent both of wood over 2¾ inches and of timber.

The largest percentage of saw-log timber does not necessarily mean production of the largest amount of all kinds of wood over 2¾ inches in diameter at the small end.

In the following table States with over 250,000 acres of woodland are arranged according to the production of derbholz:

Distribution of derbholz by States.

States.	Cubic feet per acre.	States	Cubic feet per acre.
Baden	58.4	Hesse	48.0
Wurttemberg	54.4	Bavaria	46.9
Brunswick	54.2	Pfalz	44.2
Alsace-Lorraine	51.5	On the right of the Rhine	47.0
Saxony	51.0	Saxe-Meiningen	46.2
Mecklenburg-Schwerin	48.1	Prussia	30.8

ANNUAL GROWTH AND PRESENT STAND.

Since the principle underlying the management of practically all the forests is to cut merely the annual increment and to leave intact the forest capital, it may be safely assumed that the annual cut is equal to the annual growth. In some cases the annual cut has been made smaller than the annual increment, in order to increase the forest capital so as to produce larger annual increments in the future.

The total present stand is given in the "Worterbuch der Volkswirtschaft" (Prof. D. L. Elster, Jena, Achte Lieferung, 1899), at a forest rotation of eighty to one hundred years, as from 70,000,000,000 to 105,000,000,000 cubic feet. Professor Elster assumes an annual growth of 50 cubic feet per acre, which corresponds very closely with the figure given above, 48.7 per cent. The average rotation may be taken as ninety years, but even this is too long, since there are many broadleaf forests which do not demand such long rotations. At an annual growth of 50 cubic feet and a rotation of ninety years, the forests will have a stand of about 79,000,000,000 cubic feet. At an average price even as low as 7 cents per cubic foot the German forests represent a capital of $5,530,000,000,[a] not counting the value of the land.

ANNUAL CONSUMPTION.

In spite of the fact that the German Empire succeeds in producing the largest amount of wood per acre, it is unable to supply its own needs for saw timber. Since 1863 the imports have exceeded the exports and the difference between them has been growing steadily. In 1904 this excess in saw-log timber (logs, sawn timber, and hewn timber) amounted to 4,726,000 tons, or 357,690,300 cubic feet (one ton being equal to about 75 cubic feet of round timber). This, together with the 1,706,431,900 cubic feet cut in Germany itself, gives a total home consumption of 2,064,122,300 cubic feet of wood of all kinds, or 36.6 cubic feet per capita. The consumption of saw-log timber alone is 1,064,322,000 cubic feet, or 18.8 cubic feet per inhabitant. The consumption of fuel alone is 999,800 cubic feet, or 17.8 cubic feet per capita.

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[a] Stand=annual increment×area×rotation.

WOOD PRICES.

The two following tables give the wood prices in the state forests in the different States. The second table gives the average prices of wood, irrespective of the kind and species, for a period covering seventy-four years—1830–1903. The average prices for wood of all kinds do not vary a great deal. For 1902 the prices ranged from 5 cents per cubic foot in Prussia to 10 cents in Saxony, the prevailing price being about 7 cents. The first table gives the average sale prices as they prevailed in 1902 in the state forests for saw-log timber and firewood of different species. The highest saw-log prices were secured for oak timber, and the highest firewood prices were secured for oak and beech wood.

Prices of wood of different species and kinds in Prussia and Wurttemberg.

Year.	Prussia.							Wurttemberg.			
	Saw-log timber.				Firewood.			Saw-log timber.		Billets and fagots.	
	Oak.	Beech.	Spruce.	Pine.	Beech.	Spruce.	Pine.	Oak.	Conifers.	Beech.	Conifers.
	Price per cubic foot.				Price per cord.			Price per cubic foot.		Price per cord.	
1855-59	......	......	......	......	......	......	......	$0.131	$0.079	$4.32	$2.52
1860-64	......	......	......	......	......	......	......	.172	.106	5.67	3.60
1865-69	......	......	......	......	......	......	......	.161	.090	6.03	3.51
1870	......	......	......	......	......	......	......	.177	.083	6.75	3.15
1871	......	......	......	......	......	......	......	.158	.079	6.84	3.15
1872	......	......	......	......	......	......	......	.188	.078	5.76	3.15
1873	......	......	......	......	......	......	......	.225	.102	7.47	4.14
1874	......	......	......	......	......	......	......	.209	.121	7.56	4.86
1875	......	......	......	......	......	......	......	.200	.128	8.82	5.49
1876	......	......	......	......	......	......	......	.203	.106	9.63	5.13
1877	......	......	......	......	......	......	......	.198	.098	8.01	3.96
1878	......	......	......	......	......	......	......	.195	.102	......	......
1879	......	......	......	......	......	......	......	.171	.085	......	......
1880	......	......	......	......	......	......	......	.179	.088	......	......
1881	......	......	......	......	......	......	......	.179	.089	5.49	3.24
1882	......	......	......	......	......	......	......	.176	.088	5.31	3.15
1883	$0.137	$0.088	$0.080	$0.064	$4.05	$2.61	$2.88	.173	.092	5.40	3.60
1884	.135	.085	.078	.065	4.32	2.97	3.06	.181	.090	5.58	3.87
1885	.132	.081	.075	.064	4.32	2.79	3.33	.180	.093	5.58	3.78
1886	.126	.078	.084	.065	4.23	2.79	3.15	.179	.092	5.85	3.78
1887	.125	.078	.084	.064	4.14	2.70	2.79	.169	.086	5.40	3.06
1888	.130	.083	.093	.067	4.05	2.61	2.88	.198	.097	5.49	3.24
1889	.142	.079	.099	.071	4.14	2.43	3.06	.198	.104	5.67	3.60
1890	.143	.083	.099	.074	4.23	2.61	3.24	.223	.109	5.67	4.05
1891	.144	.077	.099	.069	4.50	2.88	3.51	.230	.097	6.03	4.32
1892	.141	.080	.088	.071	4.50	2.70	3.24	.249	.102	6.57	4.77
1893	.132	.080	.085	.069	4.32	2.52	2.97	.249	.105	6.66	4.86
1894	.128	.078	.081	.061	4.14	2.34	2.70	.251	.113	6.21	4.59
1895	.134	.078	.090	.067	4.41	2.61	2.70	.237	.116	6.75	4.95
1896	.134	.082	.097	.071	4.50	2.70	2.79	.239	.119	6.48	5.04
1897	.144	.088	.107	.076	4.59	2.79	3.15	.245	.128	6.12	5.04
1898	.146	.091	.109	.083	4.50	2.79	3.60	.253	.135	6.12	5.04
1899	.148	.087	.113	.083	4.59	2.88	4.05	.269	.143	6.30	5.04
1900	.154	.088	.113	.098	5.04	3.06	4.50	.255	.139	7.02	5.46
1901	.134	.088	.097	.086	5.31	3.24	4.14	.254	.133	8.28	6.12
1902	.139	.084	.096	.078	4.68	2.97	3.33	......	......	......	......

The figures for value per cord are about 4 per cent too high because the reducing factor .9 was used instead of 0.864. The figures for values per cubic foot are 4 per cent too high because the factor 0.007 was used instead of 0.006+.

Average prices per cubic foot of wood, irrespective of kind or species, in the state forests of the different States of the German Empire.

Year.	Prussia.	Bavaria.	Saxony.	Baden.	Alsace-Lorraine.	Year.	Prussia.	Bavaria.	Saxony.	Baden.	Alsace-Lorraine.
1830	$0.02	....	$0.04	....	....	1867	$0.04	$0.03½	$0.07	$0.06	....
1831	.02	....	.04	....	....	1868	.04½	.03½	.07½	.06	....
1832	.02	....	.04½	....	....	1869	.04	.03½	.06	.06	....
1833	.02	....	.04½	....	....	1870	.04	.04	.05½	.06½	....
1834	.02	....	.04	....	....	1871	.04	.04	.07½	.06½	....
1830–34	.02	....	.04½	....	....	1866–71	.04	.04	.07	.06	....
1835	.02½	....	.04	....	....	1872	.04	.04	.09½	.07½	$0.06½
1836	.02½	....	.04½	....	....	1873	.04½	.05	.11½	.08	.08½
1837	.02½	....	.04½	....	....	1874	.05	.05½	.11	.08½	.08
1838	.02½	....	.05	....	....	1875	.05	.05½	.11½	.09	.08
1839	.02½	....	.05	....	....	1872–75	.04½	.05	.11	.08½	.08
1835–39	.02½	....	.04½	....	....	1876	.04	.06	.08½	.08½	.08
1840	.02½	....	.05½	....	....	1877	.04	.05	.08½	.07	.06
1841	.03	....	.05½	....	....	1878	.04	.05	.08½	.07	.06½
1842	.03	....	.05½	....	....	1879	.04	.05	.08	.06½	.06½
1843	.03	....	.05½	....	....	1876–79	.04	.05½	.08½	.07½	.06½
1844	.03	....	.04	....	....	1880	.04	.05	.08½	.06½	.06½
1840–44	.03	....	.05½	....	....	1881	.04	.05	.08½	.06	.06
1845	.03	....	.05½	....	....	1882	.04	.05	.08½	.06	.06
1846	.03	....	.06	....	....	1883	.04	.05	.09½	.06½	.06
1847	.03	....	.05½	....	....	1884	.04	.05	.09½	.06½	.06
1848	.03	....	.05½	$0.03	....	1885	.04	.05	.09½	.06½	.05½
1849	.02½	....	.05½	.03	....	1886	.04	.05	.09½	.06	.05½
1845–49	.03	....	.05½	....	....	1880–86	.04	.05	.09	.06½	.06
1850	.03	$0.02	.05½	.03	....	1887	.04	.05	.09	.05½	.06
1851	.03	.02	.06	.02	....	1888	.04	.05	.09½	.06	.05½
1852	.03	.02½	.06	.02	....	1889	.04½	.05	.10	.06½	.06
1853	.03	.02	.06	.02	....	1890	.04½	.05½	.10	.06½	.06
1854	.03	.02½	.06	.04	....	1891	.05	.05½	.10	.07	.07
1855	.03	.02½	.06	.04	....	1892	.04½	.05½	.09	.07	.06½
1850–55	.03	.02½	.06	.03½	....	1893	.04½	.05	.09	.07	.06
1856	.03	.03	.06	.04	....	1894	.04½	.05½	.09	.07	.06
1857	.03	.03	.06	.05	....	1888–94	.04½	.05	.09½	.07	.06
1858	.03	.03	.07	.05½	....	1895	.04½	.05½	.09½	.07½	.07
1859	.03	.03	.07	.05½	....	1896	.04½	.05½	.10½	.07½	.07
1860	.03	.03	.07	.06	....	1897	.05	.05½	.11	.07½	.07½
1861	.03½	.03½	.07½	.06½	....	1895–97	.04½	.05½	....	.07½	.07
1862	.03½	.03½	.07½	.06	....	1898	.05½	.06	.10½	.08	.07½
1856–62	.03	.03	.07	.05½	....	1899	.06	.06½	.11	.08	.08
1863	.03½	.04	.08	.06	....	1900	.06½	.07	.11½	.08½	.08
1864	.04	.04	.08	.07	....	1901	.06	.07	.11	.08½	.08
1865	.04	.05	.09	.07½	....	1902	.05	.07	.10	.07½	.07
1863–65	.04	.04	.08½	.07	....	1903	.06	....	.11	....	.07
1866	.04	.04	.08½	.06½	....						

These are average prices obtained in the state forests, including the cost of cutting and working up the timber and delivering it along the road. They refer in Prussia and Bavaria to all kinds of wood, including stump wood, in Baden to all wood except stump wood, and in Saxony only to wood having a diameter of 2¾ inches at the small end.

FRANCE.

FOREST AREA.

The forests of France have increased to some extent since 1840, as may be seen from the following table:

Increase in forest areas, 1840–1903.

	Forest area.	Land area under forest.
	Acres.	*Per cent.*
1840	20,848,274	15.9
1862	23,026,445	17.2
1882	23,367,558	17.9
1903	24,021,587	18.2

The forest area of France is considerably smaller than that of Germany or Austria-Hungary. In 1901 the per capita forest area was 0.63 acre. The total area was distributed among different owners as follows: State forests, 2,889,470 acres, or 12.0 per cent; communal forests, 5,589,392 acres, or 23.3 per cent; and private forests, 15,542,725 acres, or 64.7 per cent.

Of state forests, a large part is poorly or not at all forested; the unproductive area is estimated as 662,000 acres, or nearly 23 per cent of the total area, while in the communal forests it amounts to 275,000 acres. Most of the state forests are in the departments of Ariege (203,750 acres), in the Pyrenees, Basses-Alpes (116,328 acres), Vosges (141,180 acres), Cote-d'Or (100,743 acres), farther Loiret (96,582 acres), and Corsica (111,890 acres).

The most of the communal and institution forests are in the eastern departments of Vosges (296,638 acres), Haute Saone (287,757 acres), Cote-d'Or (251,815 acres), Savoie (188,098 acres), Doubs (249,600 acres), Hautes-Alpes (197,948 acres), Jura (215,333 acres), Meuse (242,115 acres), in the more distant parts of the three departments of the Pyrenees (322,360 acres), and in Corsica (203,405 acres).

The smallest amount of private forest is found in the department of Vosges.

COMPOSITION.

Of the total area, 20 per cent is stocked with conifers and 80 per cent with hard woods (35 per cent of this is the ordinary oak and 4 per cent of the stone oak *Quercus ilex*.) In the state forests conifers occupy 23.4 per cent of the total area (fir 7 per cent, Scotch pine 6.6 per cent, maritime pine 4 per cent, spruce 2.7 per cent, larch 1.8 per cent, other conifers 1.3 per cent); broadleaf forests 76.6 per cent (oak 27.4 per cent, beech 18.3 per cent, hornbeam 10.9 per cent, evergreen oak (*Q. ilex*) 4 per cent, other hard woods 16 per cent). In private forests conifers form 19 per cent, hard woods 81 per cent.

According to the system of management practiced, the forests show the following proportions in state, private, and communal forests:

Distribution of forests by management.

	State forest.	Forests under state control.	Private forest.	Total forest area.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Coppice	2.5	14.7	49.0	38.0
Composite forest	29.2	53.2	31.0	35.0
Conversion forest	16.8	1.0	....	2.0
High forest	51.5	31.1	20.0	25.0

ANNUAL CUT.

The total annual cut in France amounts to 910,740,000 cubic feet, of which 225,920,000 cubic feet are timber, or a total cut of 39.39 cubic feet per acre. The cut varies in the different forests, as can be seen from the following figures:

Annual cut per acre by ownership.

	Total cut per acre of forest area.	Timber.
	Cubic feet.	*Per cent.*
State forest	43.07	35
Forests under state control	36.57	24
Private forests	40.95	25
Average	39.39	25

ANNUAL GROWTH.

While France has still much work to do before she can bring the exploitation of her forests to the point the German forests have reached, it can hardly be doubted that the present cut does not exceed the annual growth. The present yield of 910,740,000 cubic feet per year may, therefore, be considered equivalent to the total annual growth. The chief task which France has in the future is to produce a larger amount of saw-log timber in proportion to cord wood, which has a small value. The 910,740,000 cubic feet of home product are not sufficient to supply all her needs, and it is necessary to import wood for home consumption. Not counting firewood and charcoal, France has at present on an average every year a surplus of imports over exports of 44,000,000 cubic feet in round numbers. On an average, between 1894 and 1898, the following amounts of the different kinds of wood were exported and imported:

Exports and imports of wood, in cubic feet.

In form of—	Exports.	Imports.	Surplus of imports over exports.
Sawn lumber	3,277,000	74,509,000	
Logs and other round timber	43,747,000	6,721,000	
Staves	212,000	6,011,000	
Other wood, except firewood and charcoal	3,101,000	8,650,000	
Total of all kinds of wood	50,337,000	95,891,000	45,554,000

As regards firewood and charcoal, there were exported 5,129,000 cubic feet and imported 3,443,000 cubic feet; in other words, the exports exceeded the imports by 1,700,000 cubic feet, which reduces the surplus of imports over exports of all kinds of wood to 43,900,000 cubic feet.

The total home consumption, therefore, amounts to 910,740,000 plus 43,900,000 cubic feet, or a total of 954,640,000 cubic feet. The per capita consumption is 24.6 cubic feet, of which 17.7 cubic feet are firewood and 6.9 cubic feet are timber.

WOOD PRICES.

The following table gives prices for saw-log timber of different species at point of shipment along the road:

Wood prices per cubic foot, according to size of log, at points of shipping for Paris market at city gates.

SAW LOGS.

Species.	Price.
Oak, heartwood	$0.28 to $0.42
Oak, sapwood	.42 to 1.10
Beech	.25 to .34
Ash	.17 to .34
Red elm	.20 to .34
White elm	.22 to .29
Scotch pine	.13 to .18
Spruce and fir	.18 to .30

RAILWAY TIES (1905).

Contents in cubic feet.	Price per tie.
4.0	$1.08
5.4	1.45
5.7	1.54
7.2	1.94
7.6	2.04

BELGIUM.

FOREST AREA.

The present forest area of Belgium shows an increase over that of 1846, as may be seen from the following:

1846, 1,200,268.8 acres; 1866, 1,074,057.3 acres; 1880, 1,209,556.8 acres; and 1895, 1,303,735.5 acres.

The forest area forms 17.7 per cent of the total land area, or 0.2 acre per inhabitant. The most wooded provinces are Luxemburg, 41 per cent, and Namur, 31 per cent, which together comprise 666,937 acres. Of the total forest area, 62,600 acres, or 4.8 per cent, are state forests; 395,452 acres, or 30.3 per cent, are communal forests; 17,370 acres, or 1.3 per cent, belong to public institutions; and 828,300 acres, or 63.5 per cent, are private forests.

COMPOSITION.

Of the total forest area, 71.1 per cent are hard woods and 28.9 per cent are conifers (pine predominating). Of the hard woods, 56 per cent was managed as composite forest, 31 per cent as sprout forest, and 13 per cent as high forest. Especially common is oak coppice wood, managed for bark, the production of which amounts to about 29,500 tons.

ANNUAL CUT.

The annual cut is estimated as 75,789,000 cubic feet, or 58.2 cubic feet per acre, of which saw-log timber forms 40 per cent, or 28,734,200 cubic feet. In addition, some 7,415,100 cubic feet are obtained annually from trees outside of the forest, making the total cut 83,204,000 cubic feet.

ANNUAL GROWTH.

During recent years Belgium has manifested a strong tendency not only to husband her forests most rationally, but also to increase the forest area. The annual cut may, therefore, be taken as the annual growth. There are no recent figures regarding the productivity.

CONSUMPTION.

Home production is unable to satisfy the needs of the country. The consumption of mine timber alone in 1894 was 21,892,210 cubic feet and in 1903 it was 35,310,000 cubic feet. The excess of imports over exports of building timber in 1898 amounted to 36,400,126 cubic feet. The total consumption then amounts to 119,604,126 cubic feet, or 17.7 cubic feet per capita. Of this amount, 72,549,400 cubic feet, or 10.8 cubic feet per capita, consist of saw-log timber; while 47,055,000 cubic feet, or 6.9 cubic feet per capita, are cord wood.

WOOD PRICES.

The wood prices are very much the same as in Germany. The average price for all kinds, irrespective of species, is something like 6 cents per cubic foot in the forest. In Germany, as we have seen, the price of wood in the forest ranges between 5 and 8 cents, while cord wood in Prussia sells at about 3 cents.

SPAIN AND PORTUGAL.

The figures regarding the forests of Spain and Portugal are extremely conflicting; thus, according to K. van Scherzer,[a] the area of Spanish forests in 1885 was 26,098,200 acres, or 20.8 per cent of the total land area; and for Portugal, according to the same source, 1,756,000 acres, or 8 per cent of the total land area. According to A. Mélard,[b] the forest area in Spain may be taken as equal to 16,065,000 acres, and that of Portugal from 1,112,400 to 1,236,600 acres. Taking Melard's figures, it would seem that the forests of Spain occupy 13 per cent of the total land area and those of Portugal 5 per cent. According to Scott Keltie,[c] the forests of Portugal amounted to only 2.9 per cent of the total land area.

The Spanish peninsula is a plateau bordered by high mountain terraces. The rivers are unreliable, having neither glaciers nor great lakes at their sources. The rains are very unequally distributed over the different seasons. Drought is often followed by severe floods, and in order to counteract their bad effects Spain and Portugal should be well forested. Both countries, however, are lacking in this respect. As to the forest area per inhabitant, taking Mélard's figures for the areas, Spain, with a population of 18,090,000, has a forest area per capita of 0.88 acre, and Portugal, with a population of

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[a] Das Wirthschaftliche Leben der Völker.

[b] Insufficance de la Production de bois d'œuvre.

[c] The Statesman's Yearbook for 1901.

5,423,000, has only 0.23 acre. These figures can not, however, be considered reliable, and if Spain actually has nearly 0.9 acre for every inhabitant the forest must be uncommonly poor, because Spain has not enough timber to satisfy rather low home demands for wood. The forests probably meet a great deal of the local demand and furnish large amounts of cork for export, but on the whole they are not sufficient to supply the home consumption. The need for foreign timber will still further increase when Spain enters on an active exploitation of her mineral wealth.

There are no figures of any kind in regard to the annual cut, growth, or consumption for either country.

ITALY.

FOREST AREA.

According to Loreto Pasqualucci,[a] the forest area of Italy now comprises 11,034,900 acres, but this figure is higher than that given in the official Italian reports.[b] The official statistics[b] of this country give the area of forests as 10,115,404.2 acres, or 14.28 per cent of the total land area. The forest area per capita is 0.31 acre.

The government ownership of forests is of two kinds. One part of the state forests, 375,000 acres in extent, is under the direct control of the secretary of the treasury, and any portion of it may be sold whenever necessary; another part, much smaller in area, comprising only 40,000 acres, is declared inalienable, is directly under the secretary of agriculture, and is administered by the forest service. The largest state forest (28,245 acres) is in Tuscany, and two other large forests (one of 16,137 acres, the other of 14,840 acres) are in Venetia.

COMPOSITION.

Of the total forest area 52 per cent is managed as high forests and 48 per cent as composite and sprout forests. Of the high forest 30 per cent is coniferous, 62 per cent produces hard woods, and 8 per cent is mixed forest. The forests are thus shown to be principally hard woods.

ANNUAL CUT.

According to official statistics the following amounts were cut in all the forests: Saw-log timber, 48,525,000 cubic feet, or 4.8 cubic feet per acre; cord wood, 222,103,000 cubic feet, or 22 cubic feet per acre, and wood for charcoal, 106,621,000 cubic feet, or 10.5 cubic feet per acre, making a total of 377,249,000 cubic feet, or 37.3 cubic feet per acre.

In addition, by-products were obtained amounting to 1,708 tons. Thus enormous quantities of cord wood and wood for charcoal were obtained.

ANNUAL GROWTH.

There are no figures regarding the productivity of the forests. It can not, however, be very far from the annual cut.

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[a] Nuevo annuario del commercio dell' Italia (1896), L. Pasqualucci.

[b] Annuario Statisco Italiano 1898 ed., 1900.

CONSUMPTION.

The 377,252,000 cubic feet which are cut at home are not sufficient to supply the needs of the home industries. Italy is compelled to import, though not to the same extent as England, Germany, France, and Belgium, because its industries are less developed. The average excess of imports of saw-log timber over exports, for a period of five years (1895 to 1899), was 27,023,000 cubic feet, and the yearly excess of imports of cord wood over exports for the same period was about 3,031,000 cubic feet. The total consumption of saw-log timber may therefore be taken as 75,548,000 cubic feet, or 2.4 cubic feet per capita. The total consumption of cord wood and wood for charcoal was 330,000,000 cubic feet, or 10.5 cubic feet per inhabitant. The aggregate consumption per capita is thus nearly 13 cubic feet.

WOOD PRICES.

No figures are available regarding the prices of wood.

NETHERLANDS.

FOREST AREA.

In the Netherlands for the last sixty-five years there has been a constant increase in the area of productive land at the expense of the noncultivated and waste land; thus, in 1833, fields, pastures, meadows, and forests occupied 63 per cent of the total land area, and the remaining 37 per cent was swamps, waste land, and roads, while in 1898, 72 per cent was under crops, forests, and gardens. In sixty-five years the Dutch have thus transformed 9 per cent of waste and unproductive land into profitable areas. Forests have also increased accordingly; in 1833 the forest area was 417,728 acres, or 5.2 per cent of the land area; in 1881 it was 552,001 acres, or 6.8 per cent of the land area; and in 1889 it was 617,567 acres, or 7.7 per cent of the land area.

The forest area in sixty-five years has increased about 50 per cent. Since the greater part is in the hands of private individuals, this increase must be taken as an indication that forestry is profitable. The per capita forest area is 0.1 acre.

COMPOSITION.

By species, the forests are distributed as follows: Two hundred and twelve thousand five hundred acres, or 37.8 per cent, are coniferous forests (pine), and 350,572 acres, or 62.2 per cent, are hard woods (chiefly oak). The sprout forest is the prevailing form of management. The oak sprout forest comprises 91,892 acres, or 16 per cent of the total forest area.

ANNUAL CUT AND GROWTH.

Unfortunately there are no reliable figures concerning the amount of annual cut. K. von Scherzer[a] estimated the cut in Holland and Belgium at 37 cubic feet per acre. Judging by the revenues obtained in the Belgian forests, the Dutch forests must yield a larger amount of wood per acre, at least 46 cubic feet. In that case the total cut would amount to 28,591,000 cubic feet. This figure may also be accepted as the annual growth, as the forests are managed for a sustained yield.

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[a] Das wirthschaftliche Leben der Völker.

CONSUMPTION.

The annual yield is not sufficient to supply the home consumption. Holland is a highly commercial nation, but its industries are less developed than those of Belgium, and hence its wood consumption is smaller. Holland uses enormous quantities of coal and turf, and therefore does not use much wood for fuel, but it needs large quantities of timber for building purposes. The surplus average of imports of round timber over exports for five years (1895–99) was about 24,875,000 cubic feet, and that of sawed timber for the same period, 13,757,000 cubic feet, or in all 38,632,000 cubic feet. Adding to this the annual cut at home (28,591,000 cubic feet), the total consumption in Holland would be about 67,200,000 cubic feet, or, with a population of 5,100,000, 13.1 cubic feet per capita. Even assuming that 50 per cent of the total cut is cord wood, still the consumption of cord wood would form only 2.8 cubic feet, while the consumption of timber and lumber would be 10.3 cubic feet per capita.

WOOD PRICES.

Except the general import prices per cubic foot as they are obtainable by dividing the total value of imports by their volume, no other wood prices are available. The general import price for round timber was about 14 cents per cubic foot, and that of sawed timber about 18 cents.

SWITZERLAND.

FOREST AREA.

The Swiss forests occupy 20.6 of the total land area of 10,237,560 acres, or 2,140,012 acres, while in 1884 the forest area amounted to only 1,940,465 acres. In other words, the forest area has increased 10 per cent during the last fifteen years. The Government recognizes the necessity of keeping the mountain slopes covered with forests in order to avoid landslides, and therefore extends the area under forest by all possible means, chiefly by planting. Between 1878 and 1890, 10,000,000 conifers and 1,000,000 broadleaf trees were planted on an average every year. Since 1890 the planting has been done every year regularly. In 1899 about 14,000,000 pine seedlings, 2,000,000 spruce, 1,200,000 larch, and 1,400,000 fir and other trees were planted. The area planted during this whole time amounted to 4,153 acres, at a cost of $22.25 per acre. The forest area per capita is 0.65 acre.

Of the total forest area, the States own 97,630 acres, or 4.6 per cent; communes and corporations, 1,431,280 acres, or 66.9 per cent; and private individuals, 611,102 acres, or 28.5 per cent. The most heavily wooded cantons are Schaffhausen, Lolothurn, Basel-Land, and Aargau; the least thickly wooded are Genève and Uri. The distribution of forests according to ownership in the different cantons is given as follows:

Distribution of forest in different cantons.

Cantons.	Forest area.	Land area under forest.	State forests.	Communal and corporation forests.	Private forests.
	Acres.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Zurich	117,150.0	27.2	4.8	41.4	53.8
Bern	380,295.0	22.1	8.5	52.0	39.5
Lucern	77,355.0	20.6	1.5	19.3	79.2
Uri	27,462.5	10.2	.7	88.3	11.0
Schwyz	42,040.0	18.5	....	85.1	14.9
Obwalden	30,487.5	25.7	.1	92.5	7.4
Unwalden	17,312.5	23.8	1.8	76.5	21.7
Glarus	26,567.5	15.4	....	92.6	7.4
Zug	12,922.5	21.6	....	73.5	26.5
Freiburg	76,875.0	18.4	10.5	48.9	40.6
Solothurn	73,010.0	36.9	3.2	76.3	20.6
Basel-Stadt	987.5	11.0	....	44.3	55.7
Basel-Land	36,237.5	34.2	....	76.9	23.1
Schaffhausen	29,055.0	39.5	16.3	70.0	13.7
Appenzell:					
Outer Rodes	14,617.5	22.4	1.5	22.5	76.0
Inner Rodes	8,310.0	20.9	1.2	34.8	64.0
St. Gallen	101,387.5	20.1	2.4	59.8	37.8
Graubunden	316,897.5	17.6	.2	89.4	10.4
Aargau	110,542.5	31.5	6.9	75.9	17.2
Thurgau	44,920.0	17.5	7.9	30.5	61.6
Tessin	151,427.5	21.5	....	82.3	17.7
Waadt	187,642.5	23.1	12.4	59.0	28.6
Wallis	192,652.5	14.7	....	94.3	5.7
Neuenburg	57,420.0	28.4	8.4	48.3	43.3
Genève	6,437.5	9.3	....	7.6	92.4
Average percentage	....	20.6	4.6	66.9	28.5

ANNUAL CUT.

Unfortunately, the latest statistics do not contain any figures for the forest cut, but the earlier statistics do contain such, and since there could not be any great change in the amount of cutting, these figures may serve our purpose.

In the early eighties the cutting, according to Professor Landolt,[a] in state forests amounted to 5,509,400 cubic feet, or 68 cubic feet per acre; in communal and corporation forests, 65,653,560 cubic feet, or 51 cubic feet per acre; and in private forests, 27,335,400 cubic feet, or 48 cubic feet per acre, making a total of 98,498,000 cubic feet, or an average of 51 cubic feet per acre.

Of the total cut, 40 per cent formed saw-log timber for building purposes.

ANNUAL GROWTH.

The cut of 51 cubic feet per acre, or a total of 98,498,000 cubic feet, may be taken as representing the annual growth of all the Swiss forests, since Switzerland has for a long time been practicing forestry and became converted to the principle of cutting only the annual increment, leaving the forest capital which produces that increment.

CONSUMPTION.

The comparatively large annual cut ought to be sufficient, apparently, for a population of about 3,000,000 inhabitants (in 1900 there were 3,117,000); but as a matter of fact Switzerland is compelled to import timber from abroad, and the figures for imports and exports for the fifteen years following 1885 show that the imports are constantly growing while the exports are constantly decreasing. Timber is obtained chiefly from Germany, Austria, and France. By aid of the figures for exports and imports and the amount cut in the forests, the wood consumption, in cubic feet, for the period from 1895 to 1899 may be determined as follows:

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[a] A. Furrer. Volkswirtschafts der Schweiz.

	Saw-log timber.	Firewood.
Annual cut	40,000,000	60,000,000
Excess of imports over exports	8,500,000	8,500,000
Total	48,500,000	68,500,000

The total consumption is 117,000,000 cubic feet, or 38 cubic feet per inhabitant. Of this, 15.7 cubic feet are in the form of saw-log timber and timber for building purposes and 22.3 cubic feet in the form of firewood.

WOOD PRICES.

The stumpage prices of saw-log timber and construction timber at the place of cutting, 1895–1899, was 8.4 cents per cubic foot, and for firewood nearly 5 cents. The average price for both timber and firewood was 6.3 cents per cubic foot. These prices are practically the same as those in Prussia.

DENMARK.

FOREST AREA.

The forest area of Denmark in 1899 comprised 623,575 acres, or 6.3 per cent of the total land area, and a per capita of 0.25 acre. The islands Seeland, Bornholm, Laaland, Falstr, and Fyen, occupying 9.3 per cent of the total area of Denmark, contain 300,137.5 acres of forest land, or 49.7 per cent of the total forest area. The other half of the Danish forests, 328,437.5 acres, or 50.3 per cent, are found on the mainland (Jutland).

The state forests comprise 23.8 per cent, or 143,702.5 acres; of this area, 45.8 per cent is found on the Danish islands and 54.2 per cent on Jutland.

COMPOSITION.

Of the total forest area 266,515 acres, or 44.2 per cent, are beech forests; 90,622 acres, or 15 per cent, are other hard woods; 228,625 acres, or 37.9 per cent, are coniferous forest; and 17,812 acres, or 2.9 per cent, are scrub growth.

Of the total area of state forests, 42,197 acres, or 29.3 per cent, are hard-wood forests (chiefly beech); 49,917 acres, or 34.8 per cent, are coniferous forests; 41,822 acres are on barren land; and 9,767 acres, or 6.8 per cent, are not on true forest soil. The area of productive state forests is therefore only 92,114 acres. The large proportion of unproductive land in the state forests is due to the vast areas of heathland found on Jutland and the island of Bornholm. It is interesting that the coniferous forests of Denmark are all planted, the first conifers having been introduced at the end of the eighteenth century. On the island Bornholm is found even the silver fir.

ANNUAL CUT, GROWTH, AND CONSUMPTION.

Unfortunately, there are no figures regarding the cut and growth or any data concerning wood consumption. Denmark fully appreciates the value of forests and treats most carefully those few which she possesses, and tries to increase the area as far as possible by planting the waste lands. Unfortunately, the area of forests is very small and the production far too little for a population of 2,300,000 inhabitants. The total productive forest area is probably not over 575,000 acres. Assuming that the forests of Denmark are producing annually as much as the forests of Holland—that is, 45 cubic feet per acre—the annual production of wood in Denmark would be 25,875,000 cubic feet. In addition to this, Denmark imports about 22,951,500 cubic feet of structural timber, or a total of 48,826,500 cubic feet. With a population of 2,465,000 the wood consumption is 19.8 cubic feet per capita.

BULGARIA.

FOREST AREA.

The agricultural statistics for 1897 credit Bulgaria with 7,169,675 acres of forests, while the forest statistics give 7,602,815 acres, or 30 per cent of the total land area. Of this, 4,375,490 acres lie within 1,200 feet of sea level, 1,614,000 acres lie between 1,200 and 3,000 feet in elevation, and 1,613,325 acres at an altitude above 3,000 feet. Only 375,000 acres of the state forests are accurately measured.

The Balkan Mountains are the most heavily wooded, especially the eastern half. Northern Bulgaria, especially the Danube region, is most sparsely wooded. In Dobrucha, along the Black Sea, dried manure is used for fuel. The forest area per capita amounts to 2.4 acres, varying from 0.2 to 10.4 acres per capita in the different provinces. The State owns 29.6 per cent, communes 51.4 per cent, and private individuals 19 per cent of the total forest area. Until 1869 the cutting of timber and grazing in the state forests were entirely free; since that year they have been brought under regulation, though not without a great deal of friction between the Government and communities.

COMPOSITION.

Hard woods (oak, beech, and, in the south, walnut) predominate. Conifers occur only in the mountains.

Bulgaria may be truly called a rural country, since five-sevenths of the total population live in villages and are engaged in agriculture. There is no rational forest management, and practically nothing is known of the condition of the forests.

SERVIA.

Data regarding Servian forests are extremely conflicting. Thus Mélard[a] gives the extent of the forests of Servia at 5,225,000 acres, or

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[a] Insuffisance des bois d'ouvre.

42 per cent of the total land area. Kolm[a] gives the forest area as 4,500,000 acres; Keltie[b], as 1,202,500 acres; and Endres as 3,864,774 acres, or 32 per cent of the land area. Since the figures given by Endres[c] are more recent, his estimate is undoubtedly the most reliable. The forest area per capita may be taken then as 1.55 acres. According to ownership the forests are divided as follows: State forests, 1,417,230 acres, or 36.6 per cent of the land area; communal forests, 1,645,650 acres, or 42.6 per cent; church and monastery forests, 42,707 acres, or 1.1 per cent; and private forests, 759,187 acres, or 19.7 per cent, making a total of 3,864,774 acres, according to Endres.

The boundaries of the different forest owners are, however, very uncertain and still disputed. The eastern part of Servia is very little wooded. Hard woods (beech and oak) occur chiefly in the east and north, while conifers (fir, spruce, pines) are found in the west and south. On the whole, the broadleaf forests predominate. Every citizen has the right to cut timber for his own needs in the state forests; it must, however, be paid for if cut for sale. Under such a system of cutting there can hardly be any regular forest management. From the fact that in 1903 Servia had an excess of imports over exports amounting to 5,846,000 cubic feet it must be inferred either that the forests are not yet opened up or that they are already ruined by abuse, because with a forest area of 1.55 acres per capita and undeveloped industries, the forests should be fully able to supply the needs of home consumption.

No figures are available regarding the cut, yield, or consumption of wood.

GREECE.

FOREST AREA.

The forests of Greece occupy 2,023,380 acres, which is less than 13 per cent of the total land area. The forest area per inhabitant is 0.83 acre. Greece was once thickly wooded, and in ancient times had a large merchant marine and navy for that period. All the ships built were supplied with wood from the neighboring mountains. Because of her large merchant marine, supplied from her forests, and the great number of warships built from the timber grown in her own forests, Greece was able to extend her commerce throughout the Mediterranean and to maintain her independence.

Now the forests are gone or are being devastated rapidly. Reckless cutting, fires, and grazing will soon complete the destruction in a country where forests are greatly needed. Nine-tenths of Greece is mountainous. The rivers have a rapid fall and resemble torrents, drying out in summer, and causing floods and destruction in autumn and winter.

Information regarding forests and forestry is extremely meager. From the fact that agriculture is at a very low level, one may safely infer that forestry is in no better condition. The chief cause of such unwise use of the natural resources must be sought in the ignorance of the people. According to Keltie, 30 per cent of all recruits admitted to military service are entirely illiterate, and only 15 per cent can read.

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[a] Serbien; W. Kolm (Semlin, 1894).

[b] The Statesman's Yearbook; Scott Keltie (London, 1901).

[c] Handbuch der Forstpolitik; Endres (Berlin, 1905).

Although industrially undeveloped, Greece has not enough wood to provide for home consumption. Annual imports amount to 275,387 cubic feet.

TURKEY.

It is impossible to obtain figures for a country which, like Turkey, does not officially recognize the value of statistics. The forest situation in Turkey is no better than in Greece. There may still be some remote corners of merchantable forest, but the country as a whole must be very poor in this respect. Here, as in Greece, the ravages of man and beast are equally severe, and in the few forests remaining the destruction exceeds production.

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The countries so far considered are those whose natural resources have been more or less fully explored and whose forests yield large quantities of materials in common use, which can be delivered at a low price to market.

The forests of the rest of the world may be and are botanically rich in species, but do not have great commercial value because they lack the kinds of wood needed in commerce and industry by the 250,000,000 people composing the most advanced and powerful nations of Europe. The richest forests in Europe, commercially, are those of Sweden, and yet botanically they are very poor, containing but two principal species, Scotch pine and spruce. The forests of the regions which were not considered in the previous pages will now be discussed under continents; and since our knowledge concerning those forests is, in the majority of cases, very meager, they can be treated only in a general way.

ASIA.

The forests of British East India, Japan, Siberia, and Caucasus were mentioned before. The forests of the Philippines will be taken up in connection with those of the United States.

CHINA.

The forests of China are practically unknown. Undoubtedly there must be some forests, since wood is used for building homes, etc. In Manchuria, in the three eastern provinces of the Chinese Empire, there are apparently large forests, but nothing is known of their extent. The species of economic importance in Manchuria are birch, alder, oak, maple, elm, cork tree, poplar, ash, fir, spruce, pine, and willow. The forests must be sufficient for local needs. As to the western provinces of China, they need foreign timber and receive it from the United States and Canada.

The imports are not very great as yet, but have increased considerably compared with the imports of the sixties and seventies. From the United States and Canada, China receives principally saw timber. Eventually, when the country enters upon active construction of railroads, the demand for timber will increase enormously. With 380,000,000 people, when it becomes an industrially developed country, China will be a large buyer of wood in the world's market.

PERSIA.

This country is almost treeless. Over the largest part of it trees grow only in parks surrounding cities. Only the Caspian provinces are rich in forests of all kinds. Here, on account of the fertility of the soil, abundance of moisture in the soil, and high temperature, vegetation is extremely luxuriant and dense. The whole northern slope of the Elburz Mountains, skirting the southern shore of the Caspian, is covered with forests. In this region many species are found—elm, oak, plane tree, cherry, plum, etc.; but the most valuable tree is the palm (*Buxus sempervirens*), from which is extracted a gum which is used by the people for chewing. It is considered very good for preserving the teeth and is a disinfectant. In Europe the *Buxus sempervirens* is used in engraving. This tree is now practically exterminated in all places where it was accessible, being now only found in the northwestern extremity of the Caspian region.

BRITISH POSSESSIONS IN ASIA.

CEYLON.

Next to East India, Ceylon is the most heavily wooded Asiatic possession of Great Britain. Its forest area is given as 6,762,880 acres, or 42 per cent of the total area of the island.

The number of species is very great, among which ebony and satinwood are the best known. In general the composition comes very close to that of British India; beside the species found in British India, the bamboo, eucalyptus, beech (*Fagus religiosa*), and a great number of others are found.

The local consumption of big timber is small. Although Ceylon exports rare woods, like ebony and satinwood, it needs timber for construction and has an excess of imports over exports.

The Ceylon climate is adapted to growing rubber trees, and this industry has been started on a large scale. At the close of 1900 there were 1,763 acres of all kinds of plantations.

THE FEDERATED MALAY STATES.

The total forest area of the Malay States is not known, except that the British Government has established several forest reserves with an aggregate area of 101,560 acres.

THE STRAITS SETTLEMENTS.

According to Mr. H. C. Heel, late inspector-general of the forests to the government of India, 88,320 acres, or 9 per cent of the total area of the Straits Settlements, have been declared reserved state forests. The colony exports a great deal of rubber, and the cultivation of rubber plants is a profitable enterprise.

CYPRUS.

The island of Cyprus, lying in the Mediterranean Sea in Asia Minor, is on the whole scantily wooded. An area of 448,000 acres is classed as forest, but many parts of this are of more or less open character. The most common tree is maritime pine. There are also found *Pinus laricio*, several species of oak, plane tree, alder, cedar, cypress, juniper, elm, and walnut. *Rhus coriaria* (the sumac of commerce), carob, and olive flourish.

TERRITORIES OF THE BRITISH NORTH BORNEO AND SARAWAK.

The total forest area of Borneo and Sarawak is not known. The territories are rich in timber and other products of the forest, as gutta-percha and india rubber. The exports of timber exceed the imports in volume.

FRENCH POSSESSIONS IN ASIA.

The forests of the Indo-Chinese possessions of France and countries under its protectorate are large, but are very little known and very little used, although they include almost the same species as are found in the forests of British India.

DUTCH POSSESSIONS IN ASIA.

Large forest areas are found in the colonies of the Netherlands, on the islands of Java and Sumatra, and part of Borneo. The forests of Java are most known. They comprise 4,920,000 acres.

AUSTRALIA AND OCEANIA.

In Australia forests in the European sense are very seldom met with, except in the form of a few thousand acres of artificial plantations. The Australian forest exists either as thicket, open forest, or chapparral growth. The tree-forest region of the mainland is almost entirely along the coast. The areas under forest in the different colonies have been estimated as follows:

Area of forests by colonies.

Colony.	Area of forests.	Land area under forest.
	Acres.	*Per cent.*
Queensland	39,680,000	9.0
New South Wales	19,840,000	10.0
Victoria	11,520,000	20.0
South Australia	3,840,000	.7
West Australia	20,480.000	3.3
Tasmania	10,880,000	65.0
New Zealand	20,480,000	31.0
Total or average	126,720,000	19.8

The distribution of forests in Australasia, as may be seen from this table, is very different in the various colonies. Thus while in South Australia the forest does not occupy 1 per cent of the total land area, in Tasmania it forms more than half the total area.

The mainland and Tasmania are the home of the eucalypts and wattles. New Zealand, especially in the northern island, is rich in conifers, of which the Kauri pine is the most valuable. The thicket forest of Australia, especially of the east coast, has a primeval character. The open forest contains chiefly hardwoods, especially the eucalypts, and the chaparral forests contain acacias.

Recently nearly all colonies have withdrawn smaller or larger areas as timber reserves, the exploitation and care of which is regulated by law. Thus in Queensland, of the 40,000,000 acres, 1,500,000 acres have been declared timber reserves; in New South Wales, of the 20,000,000 acres of timber lands, 6,000,000 acres have been withdrawn from settlement, but not in perpetuity; in South Australia, of the 3,840,000 acres, 217,000 acres were declared reserves under the forest law of 1882, but of this area only one-fifth contains timber of commercial value, the rest being stocked with stunted trees and scrub; in addition, there are 13,000 acres planted chiefly to sugar gum, pines, American ash, and other trees; in West Australia there are 20,480,000 acres of timber lands, and more than four times as much jungle covered with small trees and scrub.

In the following statement are shown the most important trees in West Australia, the areas which they cover, and the quantity of timber standing on them:

Area and stand of timber of principal species in West Australia.

Species.	Area of forests.	Total commercial timber.	Per acre
	Acres.	*Cubic feet.*	*Cubic feet*
Jarrah	8,000,000	2,000,000,000	250
Karri	1,200,000	750,000,000	625
Tuart	200,000	15,000,000	75
Other species	11,000,000	350,000,000	30
Total	20,400,000	3,115,000,000	150

No timber land has been placed in reserves. Tasmania, with 11,000,000 acres of forest, equal to 65 per cent of the total area of the island, has a reservation of 266,000 acres; it is, however, subject to revocation at any time by the governor.

The forest area of New Zealand is variously estimated at from 20,000,000 acres, or 31 per cent of the total area, to only 12,000,000 acres; by an act of 1885, 1,250,000 acres were declared timber reserves. In Victoria, of the 11,520,000 acres, 5,500,000 acres have been declared reserves under the act of 1890.

Thus the colonies of Australasia possess an area of nearly 15,000,000 acres, corresponding to the state forests of Europe. A great part of this area, however, may be reopened to settlement.

There are only fragmentary figures regarding the cut in the forests of the Australian colonies. Tue cutting is leased under a system of royalties or licensing fees. While West Australia, Tasmania, and Queensland have an excess of exports over imports, Victoria, New South Wales, and South Australia have an excess of imports over exports. For Australia, as a whole, the imports at present exceed the exports, and therefore it must be classed among the countries deficient in timber. The forest area of Australia ought to be sufficient to supply fully the local needs. New Zealand also, with its mild and moist climate and its great mountain chains and magnificent coniferous forests, resembling those of the northern hemisphere, ought to be able to supply large quantities of timber for export to her neighbors. Some statisticians, like Mélard, think that the forests of Australia have been devastated, and that a country which lives by sheep (in 1896 Australia possessed 89,745,000) can not raise at the same time both sheep and forests, as sheep require daily more extended grazing grounds at the expense of the forest. Others believe that the forests of Australia are not opened yet, and that eventually they will be fully able to supply enough good timber at least for home consumption. At present the deficit is covered by importations from the United States, Sweden, and Russia.

HAWAII.

The total area of native forests in Hawaii has recently been computed as 1,174,992 acres. In addition to this is the Algaroba forest of approximately 50,000 acres. There are established at present in Hawaii 16 forest preserves, comprising in all 444,116 acres.

The forests resources of Hawaii will be more fully discussed in connection with those of the United States.

AFRICA.

The forests of Africa are as yet very little explored. There is no doubt that in some parts of it there are to be found very valuable trees. The French and English colonies are best known.

FRENCH POSSESSIONS IN AFRICA.

ALGIERS.

In 1900 the forests of Algiers occupied an area of nearly 8,000,000 acres, a great portion of which is unproductive. The State owns 6,250,000 acres, or 77 per cent of the total; private individuals, 1,250,000 acres; and communes, 192,000 acres. Forests occupy in different parts of the country from 4 to 25 per cent of the total land area.

Botanically, the Algerian forests are very rich. The principal species are: Cork oak (1,025,000 acres), and pine (2,000,000 acres); other species cover 470,000 acres.

TUNIS AND OTHER COLONIES.

In Tunis the forests occupy 2,027,000 acres, nearly all in the northern part of the country. Like the Algerian forests, they are greatly devastated by fires and grazing. The productive area is probably not more than 1,630,000 acres. Of this the State owns 1,158,740 acres, or 77 per cent; the rest belongs to private individuals, societies, etc. The prevailing species is oak; cork oak occupies 290,000 acres; all other oaks, 117,500 acres.

The island of Madagascar has about 25,000,000 acres of forest, or 19 per cent of the total land area.

All other African possessions of France contain valuable species, but the extent of the forests is little known.

BRITISH POSSESSIONS IN AFRICA.

SOUTH AFRICA.

The total forest area of South Africa in May, 1905, was 640,902 acres.[a] This area includes the whole of South Africa south of the Zambesi, with the exception of Rhodesia and Portuguese East Africa, for which data are wanting. While there is forest of some economic importance in the Portuguese territory and on the Rhodesian plateau, none of the regions have any appreciable area of dense forest comparable to that of Natal, Cape Colony, and Transvaal. This forest area is distributed as follows among the different colonies: Cape Colony, 529,902 acres; Natal, excluding scrub forest, 90,000 acres (old Natal, 40,000, and Zululand, 50,000); Swaziland, 1,000 acres; and Transvaal, 20,000 acres; making a total of 640,500 acres.

Deducting from this total area the very poorly stocked cedar forests, there remains 524,408 acres of yellow wood (*Podocarpus elongata* and *P. thunbergii*), the most valuable species of South Africa. Of this amount, 23,535 acres are artificial plantations. As may be seen from these figures, Cape Colony contains the largest amount of forest, which represents not quite 0.3 per cent of the total area of the colony. The forest area per inhabitant in 1901 was 0.22 of an acre, which is not sufficient to supply the needs of the people.

Very little definite information exists in regard to the forest areas in the other British possessions in Africa, such as the west coast of Africa, the East Africa Protectorate, Uganda Protectorate, Central Africa Protectorate, the Soudan and Mauritius, beyond the amounts of exports of rubber and gums. One thing is certain, and that is that they do not contain sufficient timber to supply their own needs.

Mélard divides Africa, in accordance with the distribution of rainfall, into four zones, parallel to the equator: the Atlas and Mediterranean slopes; the Sahara; the equatorial zone; and the South Africa zone.

The Atlas and Mediterranean slopes comprise Tunis and Algeria and the other French colonies, the forest resources of which have been discussed above. The South African zone includes the British and Portugese possessions, the forest resources of which have also been discussed. There remains now to say a few words about the Sahara and the Equatorial zones.

The Sahara, with the exception of small oases where palms are cultivated, has no forests. Egypt belongs to the Sahara zone; it has no forests, and its demand for timber is constantly increasing as a result of the growing industries and the extension of railroads.

The Equatorial zone is supposed to contain virgin forests able to replace Canada and Sweden in the market. Mélard shows that the Equatorial forest is much less rich and extensive than has been thought. Near the Gulf of Guinea, between 10° N. and 4° S., there is a wooded area which is estimated at from 45 to 60 miles wide. East of this zone are found savannas, covered for hundreds of miles with coarse grass and scrub growth. Such is the Soudan, the

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[a] Forests in South Africa, D. E. Hutchins, Capetown, South Africa; from Science in South Africa, August, 1905.

French, and the Belgian Kongo as far east as the upper basin of the Kongo River and its tributaries, where another large forest area is found. The Equatorial zone thus consists of two great forests, one along the western coast of Guinea and the other in the center on the upper basin of the Kongo River, divided by a vast treeless area. No definite information exists about these tropical forests of Central Africa beyond the fact that they contain many precious cabinet woods, dyewoods, etc.

CENTRAL AND SOUTH AMERICA.

MEXICO.

FOREST AREA.

The area of the forests of Mexico is estimated at from 20,000,000 to 25,000,000 acres of commercially valuable timber, or 5.1 per cent of the land area. The forest area per capita is 1.8 acres. The bulk of the forests apparently belongs to the Government, which works the forests on a system of leases.

COMPOSITION.

The forests of Mexico are of two distinct kinds: The tropical forests along the coast of the Gulf of Mexico, composed of mahogany, Spanish cedar, rosewood, and other fancy woods, and the pine and oak forests of the mountains, principally in the Sierra Madre on the Pacific side of the Mexican plateau.

Of these two types, the pine forest is by far the more important from the standpoint of the timber trade. These forests are very inaccessible, however, and little is known about the character of the timber, though some idea can be gained from the fact that a tract of 1,000,000 acres, recently sold, was estimated to have a stand of 8,000 board feet per acre, composed two-thirds of pine and one-third of oak. This is probably somewhat above the average for the whole area of pine forest.

The species found in the pine forests are known as white, sugar, and yellow pines, red and white firs, and many species of red and white oaks.

ANNUAL CUT, GROWTH, AND CONSUMPTION.

The forest resources of Mexico have been very little developed as yet; the pine timber is very inaccessible and the tropical hardwood forests have been worked only to a limited extent for mahogany and cedar. Figures on the growth of the forests and the wood consumption are lacking. The annual cut of timber is given at 225,000,000 board feet of manufactured stock, or approximately 37,500,000 cubic feet of logs; and it is estimated that Mexico imports 70 per cent of its timber consumption. Assuming that this is correct, the home consumption of manufactured stock, including ties, would be 125,000,000 cubic feet, or 9 cubic feet per capita. This low consumption is due to the still undeveloped resources of the country. Whether Mexico will be able to supply its own needs of timber is questionable. At present its imports are more than three times what is cut at home. Ninety-nine per cent of all the imports come from the United States.

WOOD PRICES.

The stumpage price for pine, in the remotest and least accessible portions of the country, is as low as 75 cents per thousand feet. Standard-gage pine ties sell at 45 cents and oak ties at 57 cents apiece delivered at the railroad. Green lumber from the saw is sold at from $17.50 to $32.50 per thousand feet b. m.

Mahogany and cedar logs shipped from Gulf of Mexico points f. o. b. New York command the following prices: Laguna cedar (*Cedrella odorata*), $45 to $60 per thousand board feet; Laguna mahogany (*Swietinia mahagani*), $40 to $55; cedar from other points, $32.50 to $57.50; mahogany from other points, $30 to $50.

CENTRAL AMERICA.

The five Central American Republics possess extensive forest areas, which, however, are so little explored that there are no data as to their extent or volume. In countries which do not know even the size of their population it is unreasonable to expect any knowledge of their forests. The reason for the existence of large forest areas in Central America is not due in any way to the care of them by the people, but to the fact chiefly that they are inaccessible on account of lack of roads or any other means of transportation.

SOUTH AMERICA.

According to Semler,[a] South America has an enormous forest wealth. With the exception of the prairies of Uruguay and Argentina, most of the continent is covered with forests. The whole chain of the Andes Mountains is wooded, the forests, according to altitude, latitude, and exposure, being of different composition. The cutting has not as yet impaired their value, because, first, the countries of South America are still very thinly settled; and second, which is more important, there are comparatively few rivers suitable for transporting timber to the coast. Not a single State has made any forest survey or has any clear idea of its forest resources.

The eastern coast of South America, south of Rio de la Plata to the Straits of Magellan, is extremely sparsely wooded. Only here and there are found a few thorny acacias, and along the rivers individual groups of willows, and occasionally antarctic beech, forms larger stands. In remarkable contrast to these are the islands of Tierra del Fuego, which, according to Darwin, are completely covered with forest.

North of the Rio de la Plata in Uruguay one finds small forests along the rivers, which have no commercial value, but which supply the needs of the few people who live there.

An entirely different picture is presented in Paraguay, whose slopes toward the Parana River are covered with almost impenetrable forests. On the slopes toward the Paraguay River are the settlements; here is open grass land, and only the hills, as a rule, are wooded. According to a statement, which, however, needs confirmation, there are seventy kinds of woods which are commercially useful, two of which, lapacho and quebracho, were used by the Jesuits in constructing their missions and are still well preserved in the ruins. Fifteen kinds of trees yield dyewoods, and eight yield fibers.

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[a] Tropische und Nordamerikanische. Waldwirtschaft und Holkunde—Heinrich Semler, Berlin, 1888.

The forests of Brazil cover an area equal to one-half of Europe. The Amazon flows for a distance of 1,860 miles through a virgin forest which stretches 1,100 miles from east to west and 750 miles from north to south, and occupies an area of 825,000 square miles. Many of the Brazilian woods have excellent properties. The following are among the most valuable: Pernambuco (*Cæsalpinia echinata*), fustic (*Macluria tinctoria*), both of which occur only near the coast; Jacaranda, ironwood (*Cæsalpinia ferrea*), and cedar (*Cedrela brasiliensis*). The forests yield other valuable products, as rubber, Brazil nuts, Paraguay tea, guarana, gums, and resins.

Guiana is relatively just as rich in forests as Brazil, especially British Guiana, which has the advantage of four large rivers which, with their tributaries, are very suitable for floating logs. For this reason the exploitation of these forests has advanced further than in any other part of the country. British Guiana furnishes two of the most valuable trees for shipbuilding—greenheart (*Nectandra rodeæi*) and mora (*Mora excelsa*). Greenheart is the more important, and is so hard that it nicks the axes of choppers and will last for over one hundred years in water. Dutch Guiana has a very important wood in the purpleheart (*Copaifera bracteata*), which is suitable for the use of wheelwrights. French Guiana has a very important wood, so-called violet wood (Bois violette—*Copaifera bracteata*), which is especially suited for woodworking.

Venezuela is for the most part a prairie. Its most extensive forests are found on the lower course of the Oronoco River. The home production hardly exceeds the home consumption, the only wood that is exported being *Zygophillum arborea.*

Colombia, though partially a prairie State, possesses more forests than Venezuela. The exports, however, are insignificant because of lack of transportation facilities. Ecuador and Peru are in the mountain region of the Andes, and have exceptionally luxurious and extensive forests, which are, however, entirely inaccessible. Both of them import wood from North America.

The northern part of Chile has no forests. Forests are found only in the south, beginning at San Jago, especially in the provinces of Arauco, Valdivia, and Chiloé, but are rapidly disappearing, not on account of any great drain upon them for home consumption or export, but because the land is needed for agriculture. The forests are burned and treated by the people as an enemy, as was the case in this country at the time of the earliest colonization.

While at present South America imports some timber, it is hardly to be expected that these imports will greatly increase in the future. On the contrary, they will probably decrease, as the forests become opened up and are made more accessible.

WEST INDIES.

Semler takes a very gloomy view of forest conditions in the West Indies. He thinks that on the whole the West Indies present a sad picture of forest destruction. The small islands are robbed of their former forest wealth; and the large ones, like Jamaica, San Domingo, and Cuba, have only remnants. What little is left is almost entirely in the hands of private individuals, and nothing is done for the preservation of the forests.

John T. Rea,[a] who lived for four years in the West Indies, takes a more optimistic view of the situation, and since his observations are more recent and many of them are original they are apparently more trustworthy than Semler's. According to Rea's statement, two-thirds of most of the West Indian islands are still in virgin brush and forest, which are capable of yielding a plentiful supply of good material. Thus the Layon and Sara flats, or crown lands of Dominica, have an area of 40 square miles, and contain a mine of wealth in timber. In Trinidad, he estimates that there are at least 300,000 acres of forest land.

The total area of the West Indies is about 100,000 square miles. The trees on the whole are not very large, and yield as a rule only small scantlings. Some of the woods are useful for building and engineering work, but they are valuable principally for furniture, paneling, cabinet, and other fancy work. The immense variety of small articles, such as knife handles, knobs, buttons, etc., which are now manufactured from choice grained woods, opens a ready market for many West Indian timbers, the beauty of which can not be surpassed. Gum and resin yielding trees abound, and commercially valuable fibers may be stripped from quite a number of them. The bark, leaves, and berries of others furnish well-known drugs, dyes, and spices. Owing to the fact that all the best timber is in the inland forests with few convenient rivers for floating it down, and owing also to the defective character of the means of communication and the absence of sawmills and machinery for their treatment, the native woods have until lately been available only in small quantities. Circular and other rapid saws have been added to the plant of most of the public work yards, so that some of the disabilities have been remedied.

Little definite information is to be had concerning the forest area of Cuba. It probably does not exceed 5,000,000 or 6,000,000 acres, which, with a population of 2,050,000, makes the area per capita about 3 acres, and constitutes about 20 per cent of the total land area. Such an area with the small local demand for wood, if the forests are properly managed and cared for, certainly ought to furnish a sufficient supply for home consumption. Unfortunately, however, the forests do not contain the kinds of timber needed for most purposes, and hence large quantities are imported annually.

FOREST RESOURCES OF THE UNITED STATES AND HOW THEY COMPARE WITH THOSE OF OTHER COUNTRIES.

A detailed discussion of the forest resources of the United States is taken up under several other topics in the report to the commission. Here it is intended merely to compare the most important features of the forest resources of this country with those of other countries. This, perhaps, will serve at the same time as a summary of the statistical facts brought out in the preceding pages.

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[a] The Indian Forester, Dec., 1902, p. 44a, "West Indian Timbers."

FOREST AREA.

The United States occupies the second place among the nations of the world as to the extent of its forests; Russia, European and Asiatic, comes first; Canada stands third.

The forests of the United States, according to ownership, may be roughly divided as follows: National forests, 100,000,000 acres, or 18.35 per cent; state forests, 3,000,000 acres, or 0.55 per cent; and private and unreserved public forests (unclassified), 442,000,000 acres, or 81.1 per cent.

The bulk of the forests is either in private hands or likely to pass into private ownership.

While government and state ownership of forests has invariably proved the most advantageous form, yet the proportion of forest land owned or controlled by the State can not always be taken as a criterion of the state of development of forestry in the country. The Government may, for historic or economic reasons, have only a small area of its own, but still exercise a great influence over the forests of other owners. Thus, Austria has only 10.7 per cent of the total forest area under state ownership, Switzerland 4.6 per cent, France 12 per cent, and yet forestry in those countries is at a high state of development, as all other forests are under direct control of the State, which practically amounts to management by the State.

Government and state forests comprise about 19 per cent of all forests; since the bulk of the forests is in private hands and entirely outside of state supervision, the area which is assured of a proper and careful management is comparatively small. Below is given a comparative table of forests under state ownership in the different countries of the world:

Percentage of forests under state ownership.

Country.	Per cent.	Country.	Per cent.
Great Britain	2.2	Norway	28.5
Italy	4.0	Bulgaria	29.6
Switzerland	4.6	German Empire	31.9
Belgium	4.8	Sweden	36.5
Portugal	8.0	Servia	36.6
Austria	10.7	Roumania	40.0
Croatia and Slavonia	11.0	Finland	61.2
France	12.0	European Russia	69.0
Hungary	15.0	Bosnia and Herzegovina	78.6
Denmark	23.8	Spain	84.0
United States (National and State)	18.9		

To supplement this table, it may be added that in the German Empire 66 per cent of the total forest area is under state control. In Austria, Hungary, France, Switzerland, Italy, Sweden, and Denmark the private forests are under state control; and for this reason the forest area under state supervision is much larger than the figures in the above table would indicate.

The forests of the United States form less than 29 per cent of the entire land area. The following table gives the forest area and percentage of the entire land area under forests, by States and Territories. The forest area per inhabitant is about 8 acres, corresponding closely to that in Sweden and Norway.

Forest area of the United States, by States and Territories, 1908.

State or Territory.	Land area (acres).	Forest area.	
		Acres.	Percentage of land area.
Alabama	32,818,560	20,000,000	61
Arizona	72,857,600	14,000,000	19
Arkansas	33,616,000	24,200,000	72
California	99,896,880	24,000,000	24
Colorado	66,341,120	12,000,000	18
Connecticut	3,084,800	1,000,000	32
Delaware	1,257,600	350,000	28
Florida	35,111,040	20,000,000	57
Georgia	37,584,000	22,300,000	59
Idaho	53,618,560	20,000,000	37
Illinois	35,841,280	2,500,000	7
Indiana	22,966,400	4,000,000	17
Iowa	35,575,040	2,500,000	7
Kansas	52,335,360	1,000,000	2
Kentucky	27,715,840	10,000,000	36
Louisiana	29,061,760	16,500,000	57
Maine	19,132,800	14,900,000	78
Maryland	6,362,240	2,200,000	35
Massachusetts	5,144,960	2,000,000	39
Michigan	36,787,200	15,500,000	42
Minnesota	51,749,120	15,500,000	30
Mississippi	29,671,680	17,500,000	59
Missouri	43,985,280	18,300,000	42
Montana	93,296,640	18,000,000	19
Nebraska	49,157,120	800,000	2
Nevada	70,285,440	5,000,000	7
New Hampshire	5,779,840	3,500,000	61
New Jersey	4,808,960	2,000,000	42
New Mexico	78,401,920	12,000,000	15
New York	30,498,560	12,000,000	39
North Carolina	31,193,600	19,600,000	63
North Dakota	44,917,120	600,000	1
Ohio	26,073,600	4,800,000	18
Oklahoma	44,424,960	8,000,000	18
Oregon	61,188,480	27,000,000	44
Pennsylvania	28,692,480	9,200,000	32
Rhode Island	682,880	250,000	37
South Carolina	19,516,800	12,000,000	61
South Dakota	49,195,520	1,200,000	2
Tennessee	26,679,680	15,000,000	56
Texas	167,934,720	30,000,000	18
Utah	52,597,760	6,000,000	11
Vermont	5,839,360	2,500,000	43
Virginia	25,767,680	14,000,000	54
Washington	42,775,040	25,000,000	58
West Virginia	15,374,080	9,100,000	59
Wisconsin	35,363,840	16,000,000	45
Wyoming	62,460,160	10,000,000	16
Total	1,903,423,360	544,400,000	29

COMPOSITION.

The species which are most valued in international trade are the conifers, such as pine, spruce, hemlock, fir, and larch. Coniferous forests, on the whole, as German experience has shown, produce a larger percentage of structural timber than hard woods. In Germany, therefore, there is a tendency to increase the area under conifers at the expense of that under hard woods. This tendency is also often prompted by necessity. Hard woods, as a rule, require better soil than conifers, and in countries where there is need for more agricultural land to provide for an increasing population, the forests are more and more relegated to the poorer soils where conifers can be grown to better advantage than hard woods. The forest wealth of a country is therefore determined not only by the extent of the forest, but also by the species that make up the forest. As has already been pointed out, the richest forest, from a commercial standpoint, is that of Sweden, which consists chiefly of but two species, pine and spruce. In this country, as a result of the reckless cutting of conifers, especially in the northeastern States, and of repeated fires, thousands of acres of coniferous forests in New England have been converted into poor hard-wood forests. In the Catskills one finds thousands of acres originally covered by hemlock now under scrubby hard woods, and the same is true in Maine and New Hampshire. If the soil is at all suited to hard woods, they are favored in reckless cutting and burning because of their sprouting capacity. Thus, while Germany has increased its area of coniferous forests, the area of hard-wood forests in this country has probably increased at the expense of the coniferous forest area. Below are given the countries and the predominance of either hard woods or coniferous forests:

Distribution of hard woods and conifers, by countries.

Hard woods predominate.	Conifers predominate.	Hard woods predominate.	Conifers predominate.
Australia and Oceania.	Russia.	Spain.	Germany.
British India.	Finland.	Portugal.	Austria.
Hungary.	Canada.	Italy.	Switzerland.
Croatia and Slavonia.	United States.	British Isles.	
France.	Sweden.	Holland.	
Japan.	Norway.	Denmark.	

It is hard to tell what proportion of the total forest area of the United States is under hard woods. From the rather conflicting estimates of the present stand of conifers and hard woods it would seem that the proportion of conifers to hard woods by volume is about 4 to 1 (on the basis of Doctor Fernow's estimate of 2,000,000,000,000 feet b. m. of both kinds, and the estimate of 400,000,000 feet b. m. of hard woods by the American Lumberman).

Of all the countries of the world the United States is the only one which has such a variety of conditions as to favor the growth of a great number of valuable species, both conifers and hard woods, over large areas.

PRESENT STAND.

The latest and best estimate of the stumpage of the United States places it at 2,500,000,000,000 feet b. m. This, however, does not represent the forest capital in the sense in which does the estimate of 944,700,000,000 board feet of the German Empire. In Germany the estimated stand is a constant quantity, a capital, which is capable of producing annually some 50 cubic feet per acre. In this country the stumpage represents a capital which is annually drawn upon, since the cut does not represent the annual growth but exceeds it. With an annual cut of about 23,000,000,000 cubic feet of standing timber and a forest area of about 545,000,000 acres, the cut per acre is 42 cubic feet, while the annual growth on the area has been estimated at 12 cubic feet per acre.

The United States is not the only country which at present cuts more than is annually produced. The different countries may be divided according to whether they cut more than the forest produces, less, or just the same amount. In the following table are brought together the data available from the different countries of the world concerning the annual cut and the annual growth per acre.

Annual cut and annual growth per acre, in cubic feet, for various countries.

	Annual growth.	Annual cut.
Countries which overcut.		
Austria	42.4	60-67 } 53.00
Hungary	44.4	30-33
Croatia-Slavonia	43.4	30-33
Canada	20.0	[a]17.00
Norway	11.3	....
Roumania [b]	....	....
Spain [b]	....	....
Portugal [b]	....	....
Greece [b]	....	....
Turkey [b]	....	....
Bulgaria [b]	....	....
United States	12.0	42.00
Countries which cut just the annual growth.		
Germany	48.7	48.70
France	37.9	37.90
Switzerland	51.0	51.00
United Kingdom	45.5	45.50
Belgium	?58.2	?58.20
Holland	46.0	46.00
Denmark	....	....
Italy	37.3	37.30
Countries which cut less than the growth.		
Russia	31.0	17.00
Finland	19.8	[c]3.44 [d]20.00 } 13.60
Sweden	25.0	19.10
British India	....	3.00
Japan	....	35.00
Servia	....	....

[a] Plus great fire loss, estimated at 170 cubic feet per acre.

[b] No definite figures on these countries, but facts indicate that they are being overcut.

[c] State forests, 38.7 per cent.

[d] Private forests, 61.3 per cent.

While in a general way these figures indicate the annual cut and growth in the different countries, yet they do not tell the whole story. They represent the total amount of wood cut and produced, irrespective of kind.

In most of the countries where at present the forests are being overcut, and they are the countries which still contain virgin timber, the proportion of structural timber to firewood in the cut is much greater than will be the case in the second growth. The figures would indicate that out of 23,000,000,000 cubic feet of wood cut annually to supply the forest products, 9,000,000,000 feet (allowing 90 cubic feet per cord), or 39 per cent, is firewood. This percentage of firewood appears to us too high, but if it is correct, then the proportion of saw-log timber in the second cut will certainly be less than half of the total amount of wood produced annually, because the forests under the present system of cutting do not improve, but deteriorate in quality. This holds true not only of the United States, but of Canada, Austria, and Norway, while the reverse is true of countries like Germany and France, where the percentage of saw-log timber is gradually increasing through proper methods of management.

The cut per acre in such countries as Canada, the United States, and Russia does not represent the actual cut per acre, because these figures do not always refer to the actual productive forest area, but include a great deal of unproductive land, such as swamps, burns, etc. If the figures referred only to the productive-forest area, if that could be known, the cut per acre would be much higher.

On the whole, the figures of annual cut and growth show a sad state of affairs. Countries which with proper care for their forest resources could continue to be a source of timber supply to many other countries deficient in wood are, with a few exceptions, overcutting their forests and rapidly deteriorating them, and in those few countries with large forests which do not overcut the resources are deterred only through want of capital or lack of natural means of transportation, such as rivers, etc. On the other hand, some other countries, though they have not enough forests to supply their own needs, continue to deplete what little they possess.

From the figures of annual growth and cut in the United States it would appear that the cut is more than three times the growth. In point of fact, however, the depletion of our forests goes on much more rapidly, owing to loss by fire on account of the lack of protection given the forests.

ANNUAL CONSUMPTION.

The consumption of wood is different in different countries, being dependent on the industrial development, on the presence of coal for fuel, and of substitutes for structural timber. In the following table are brought together the total annual consumption and the consumption per capita in the various countries of the world:

Annual and per capita consumption, in cubic feet, of various countries.

Country.	Total annual consumption.	Consumption per capita.		
		Total.	Timber.	Firewood
United States	23,000,000,000	260.0	160.0	100.0
Canada	1,111,209,625	192.0	60.0	132.0
Norway	276,000,000	125.0		
Sweden	404,000,000	120.0		
Finland	237,000,000	91.5		
Russian Empire (exclusive of Finland)	6,576,280,000	63.0	25.0	38.0
Austria-Hungary	2,500,000,000	57.0	28.5	28.5
Switzerland	117,000,000	38.0	15.7	22.3
Germany	2,064,122,300	36.6	18.8	17.8
Japan		30.0		
France	954,640,000	24.6	6.9	17.7
Denmark	48,826,500	19.8		
Belgium	119,604,126	17.7	10.8	6.9
United Kingdom	670,890,000	14.0	12.8	1.3
Holland	67,200,000	13.1	10.3	2.8
Italy	405,548,000	13.0	2.5	10.5
British India	236,611,600	.8+		

Thus the home consumption of the United States is larger than that of any other country in the world. While the exports amount to 2,600,000,000 feet b. m., the imports in 1907 were 1,700,000,000 feet b. m., or an excess of exports over imports of only 900,000,000 feet b. m., or 150,000,000 cubic feet, a practically insignificant amount. Therefore, the annual cut of 23,000,000,000 cubic feet may be taken as the home consumption of the United States.

WOOD PRICES.

There is a certain relationship between the wood prices of a country and the care which the forests receive. In countries with large forests and sparse population, wood prices are low and there is very little forest protection. In the following table are given wood prices on the stump for some leading European countries and for the United States.

Wood prices on stump in various countries.

Species.	Price of structural timber per cubic foot.			
	United States, 1907.	Prussia, 1902.	Wurttemberg.	Hungary, 1901.
Oak	$0.04	$0.14	$0.25	$0.038-$0.11
Beech	.02	.084	....	.067
Spruce [a]	.033	.096	....	....
White pine [b]	.05	.078	.13	.034- .067

Species.	Price of cordwood per cord.			
	United States, 1907.	Prussia, 1902.	Wurttemberg.	Hungary, 1901.
Oak	$1.00	$4.68	....	$0.60-$3.20
Beech	1.00	4.68	$8.28	1.31- 2.60
Spruce	....	2.97	....	....
Pine	.75	3.33	6.12	....

[a] Eastern spruce only.

[b] Eastern white pine.

These figures simply give an idea of the relative value of wood in different countries. A comparison of wood prices is extremely difficult, because prices do not always include the same items. In some countries the prices include transportation to points of shipment, in others they refer to partly finished products, etc. The few figures given in the above table all refer to the price on the stump. The stumpage prices for the United States are taken from Bulletin 77, page 40, Forest Service, and 167 cubic feet are assumed to equal 1,000 board feet. The prices in the United States are mainly those in the East, and are probably higher than if western species were chosen. As it is, oak timber, probably much poorer in quality than the white oak in this country, brings in Prussia over three times as much on the stump, and in Wurttemberg over six times as much as here. The same holds true for other species, except white pine, which in New Hampshire and the Northeast is at present bringing prices approaching those obtained by Scotch pine in Prussia and Hungary. In Wurttemberg, however, Scotch pine brings close to three times as much as white pine in this country. The prices for cord wood in European countries are also much higher than in this country. We excluded cord wood of spruce and pine in this country, since they are used for pulp, and it would not be fair to compare them with wood used for firewood in other countries.

The difference in the wood prices here and in European countries is very great indeed, but still they do not show the actual difference in the value obtained from timber in this and other countries. These figures refer only to the used part, which is much greater in Europe than here, and therefore the difference between the stumpage value per tree obtained in this country and abroad must be still greater.

Part II.—HOW FAR CAN WE COUNT ON FOREIGN SOURCES OF SUPPLY?

SUMMARY.

It is obvious that if the forest resources of the United States fail we must increase our imports of wood from other countries. It is equally obvious that if the net imports of the present wood-importing countries are increased, they will compete with the United States for wood from other countries. This will necessitate a still greater output of timber from wood-exporting countries. With these considerations in mind concerning the timber trade of the principal wood-producing and wood-using countries of the world, we reach the following conclusions:

EUROPE.

Europe both imports and exports more than one billion cubic feet of wood yearly. The imports, however, exceed the exports by about 10 per cent, the excess being made up chiefly by supplies from Canada and the United States. A brief summary of European conditions is as follows:

First. The leading import countries—that is, Great Britain, Germany, France, Belgium, Switzerland, etc., are rapidly increasing the amount of their imports, and this increase is certain to continue.

Second. Russia, Finland, and Sweden only of the export countries have increased their exports to great extent without encroaching on their timber capital.

Third. Norway and Austria-Hungary are already overcutting their forests and will in all probability have to reduce their exports in the future.

In view of these facts and considering the rising prices of wood throughout the world, it is certain that any increase of wood exports from Russia, Finland, and Sweden will be eagerly competed for by Great Britain, France, and Germany, and also that there will be no surplus of any consequence for the United States, which is handicapped by its greater distance from the principal source of supply.

AFRICA.

Both north and south Africa are importers of timber and these imports will increase with the increased development of the country. The forests of central Africa are little known, but it is certain that their area is not so great as was once commonly supposed. The chief species of commercial value in that section are hard woods, which are expensive, and which have little bearing on the question of the supply of common timber for use in the United States.

ASIA.

India, the chief forest country of Asia, exports teak and some other valuable woods, but it is necessary for it to import structural timber. China is a wood-importing country, and its requirements will undoubtedly take the most of any surplus that may come from eastern Siberia and Manchuria. If only structural timber is considered, Japan is a wood-importing country, but if all woods are considered, it is a wood-exporting country. Japan can supply its own needs when all the forests become accessible, but will probably not be able to export any saw-log timber.

AUSTRALASIA.

Australia is a wood-importing country at present, and it is not likely that there will ever be much surplus timber for export. With the exception of comparatively small quantities of hard woods, the forests of Hawaii can never become important in the timber trade of the world. The Philippines at present import much more timber than is exported. Eventually the native forests should supply the principal demands of the home market with a considerable excess for exportation to near-by countries, such as China. The total stand of commercial timber in the Philippines, however, is no greater than the amount of timber annually cut for lumber in the United States. Hence the islands will never become an important factor in supplying our needs for wood.

TROPICAL AND SOUTH AMERICA.

Mexico, the West Indies, and Central America now import timber, not so much because they have none, but for the reason that their stands are at present inaccessible. It is probable that they will for some time continue to import the common structural timbers and will export valuable woods, such as mahogany and cedar.

For many years South America will continue to export hard wood, dye wood, etc., and to import lumber and construction material. When the great forests of the Andes and the interior are opened up then they will supply the home market. Wood consumption will have so increased in South America by that time, however, and logging and transportation will be so expensive because of the comparative inaccessibility of the forests, that it is not reasonable to expect any considerable exportation of timber suitable for common uses in the United States.

NORTH AMERICA.

The total stand of timber in Alaska is probably no greater than twice the amount of lumber annually cut in the United States. The Alaskan industries require a considerable proportion of the output of the home forests, so little will remain for export to the United States.

Canada is the only country from which the United States is importing any considerable amount of timber. The total amount of standing timber in Canada, however, is estimated at no more than one-quarter of that in the United States. The Canadian forests are probably being cut and burned faster than they are growing, and this, with the rapid development of the Canadian provinces, will require all that the forests will eventually produce.

CONCLUSIONS.

A review of the timber trade of the various timber countries of the world shows a steady increase in the wood consumption and imports of nearly all of the leading countries, and but three important countries, Russia, Finland, and Sweden, can increase their exports without reducing their forest capital. This increase will be needed in western Europe to make up the growing deficit there and will not be a source of supply for the United States.

The tendency is toward a greater cutting of timber by the wood-exporting countries to make up the increasing deficit of the wood-importing countries. This policy, if continued, would lead to a universal shortage with no surplus to draw upon. There is no doubt, however, that there is enough accessible actual and potential forest land in the civilized countries of the world to produce, under proper management, an abundance of timber to supply indefinitely the world's growing demand.

This country must, so far as possible, depend upon itself. A considerable proportion of the present forest area of the United States will undoubtedly be cleared for agriculture as the population increases. The area of land in the United States so situated as to be permanent forest land is about 400,000,000 acres. The inevitable increase in wood consumption, following the increase in population and growth of industries, will thus have to be supplied from the diminished forest area. This means that the land should be surveyed and classified by the Government as permanent forest land before it is too late.

INTRODUCTION.

After the above-detailed discussion of the forest resources of the various countries of the world, the question naturally arises, How far, in case our own resources fail, can we count on foreign sources of supply? It is obvious that there must be an increase in exports of some countries, in event of a failure of our timber supply, to make up our deficiency. It is equally evident that if the amount of net imports of present importing countries should increase, they would compete with the United States in case it should run short, and thus necessitate a still greater output of timber by the exporting countries.

It is important, therefore, to trace the tendencies of the timber trade of the various countries for the last few years to see what deductions can be drawn as to the future, bearing in mind their resources, as brought out in Part I, and trying to bring out the reason why they import or export. The following table[a] shows the amount of net exports or imports of the important countries of the world:

Net exports and imports of various countries, yearly average, 1897–1901.

Country.	Net exports.		Net imports.	
	Cubic feet.	Feet board measure.[a]	Cubic feet.	Feet board measure.[a]
Russia (with Finland)	295,000,000	2,300,000,000		
Sweden	223,000,000	1,784,000,000		
Austria-Hungary	183,500,000	1,460,000,000		
Canada	107,200,000	857,600,000		
Norway	52,000,000	416,000,000		
United States	51,000,000	408,000,000		
Roumania	3,000,000	24,000,000		
India	2,750,000	22,000,000		
West coast of Africa	1,300,000	10,400,000		
West Indies, Mexico, Central America	650,000	5,200,000		
Alaska			170,000	1,300,000
Japan[b]			250,000	2,000,000
Ceylon			500,000	4,000,000
Servia			750,000	6,000,000
Mauritius			1,000,000	8,000,000
Greece			1,750,000	14,000,000
Philippine Islands			2,000,000	16,000,000
Bulgaria			2,500,000	20,000,000
China			2,500,000	20,000,000
Natal			2,500,000	20,000,000
Portugal			3,000,000	24,000,000
Cape of Good Hope			7,500,000	60,000,000
Australia			8,000,000	64,000,000
Switzerland			8,500,000	68,000,000
Holland			9,000,000	72,000,000
Egypt			10,000,000	80,000,000
Spain			10,500,000	84,000,000
South America			16,500,000	132,000,000
Italy			21,000,000	168,000,000
Denmark			23,500,000	188,000,000
Belgium			51,000,000	408,000,000
France			61,500,000	492,000,000
Germany			230,000,000	1,840,000,000
British Isles			464,500,000	3,716,000,000

[a] Since the figures include lumber, logs, poles, and split wood, 1 cubic foot was regarded as equivalent to 8 board feet. In the original conversion from tons, 1 ton is regarded as equivalent to 50 cubic feet.

[b] Schlich includes only construction timber; judged by value. Japan is an exporting country.

The relation between forest area per capita and export or import of timber can be seen from the following table:[b]

It will be noticed that countries with 92 or more acres per 100 inhabitants have a surplus of exports over imports, while those with 85 acres or less have a surplus of imports over exports.

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[a] Schlich: The Outlook of the World's Timber Supply.

[b] Zon: The Future Use of Land in the United States.

Relation between forest area per 100 inhabitants and exports and imports of the different countries.

Country.	Forest land per 100 inhabitants.	Excess of exports over imports.[a]	Excess of imports over exports.[b]
Exporting countries.	*Acres.*		
Canada	2,400	$26,551,000	
Finland	1,850	14,970,000	
Sweden	952	34,770,000	
Norway	702	9,585,000	
United States	620	13,450,000	
Russia (Europe)	462	23,039,000	
Bosnia-Herzegovina	405	2,632,500	
Bulgaria	230		[b] $407,000
Servia	155		[b] 148,000
Roumania	127	961,000	
Hungary	116	32,751,000	
Austria	91		
Japan	91	126,000	
Importing countries.			
Greece	85		873,000
Switzerland	66		3,653,000
German Empire	61		48,750,000
France	61		19,270,000
Italy	32		5,964,000
Denmark	25		4,817,000
Belgium	20		16,330,000
Netherlands	10		5,945,000
Great Britain	7		93,950,000

[a] Average for five years, 1895–1899.

[b] Timber land largely in mountains and difficult of access. These countries will in time become exporters instead of importers.

DIVISION INTO EXPORTING AND IMPORTING COUNTRIES.

Since there are more statistics available for the countries of Europe than for others, they are first considered in detail in the order in which they occur in the following outline:

1. *Import countries.*—These may be subdivided into the four following groups, according to the reasons for their being import countries:

(*a*) Countries which, with a highly developed forest management and important forest possessions, themselves produce much wood, but in spite of this, on account of their important industries, can not do without foreign wood: German Empire, France, Switzerland, Belgium.

(*b*) Countries in which forest management plays but a small part on account of the small forest area: Great Britain, Netherlands, Denmark.

(*c*) Countries with only slightly developed forest management and little wood consumption: Italy, Spain, Portugal, Greece.

(*d*) Countries with relatively large forest areas, which, however, are in large part not yet fully developed, unequally distributed, or poorly managed: Servia, Turkey, Bulgaria.

2. *Export countries.*—These are Russia (with Finland), Sweden, Norway, Austria-Hungary (with Bosnia-Herzegovina), and Roumania.

IMPORT COUNTRIES.

EUROPE.

GERMAN EMPIRE.

Germany is unable to produce enough timber to satisfy its needs, and there is no doubt this condition will continue in the future.

Since 1863 the imports have exceeded exports, and the difference between them has been growing steadily, as shown in the two following tables.

It is worthy of note that since 1899 Austria-Hungary has taken Russia's place as the chief wood supplier of Germany. This is largely due to the greater development of the sawmill industry in Austria-Hungary, and to the fact that railroad communication is much better. Russia exports nearly all material by water.

If the average yearly import of the period 1880–84 is taken as a standard equal to 100, then imports have increased as follows:

Total timber imports and exports of Germany.[a]

Year average of—	Imports.		Exports.		Excess of imports.	
	Tons.[b]	Value.	Tons.	Value.	Tons.	Value.
1862-65	1,314,000	....	1,181,000	....	133,000	....
1866-71	1,963,000	....	879,000	....	1,084,000	....
1872-75	3,633,000	....	1,153,000	....	2,480,000	....
1876-78	3,190,000	$43,875,000	1,183,000	$17,500,000	2,007,000	$26,375,000
1879-84	1,990,000	22,400,000	731,000	10,000,000	1,259,000	12,400,000
1885-87	2,253,000	22,400,000	501,000	6,425,000	1,752,000	15,975,000
1888-96	3,051,000	36,575,000	302,000	4,050,000	2,749,000	32,525,000
1897-1901	4,637,000	63,800,000	329,000	5,550,000	4,308,000	58,250,000
1902	3,932,000	46,400,000	342,000	5,575,000	3,590,000	40,825,000
1903	4,797,000	55,125,000	371,000	6,175,000	4,426,000	48,950,000
1904	5,049,000	59,475,000	323,000	5,825,000	4,726,000	53,650,000

[a] Endres: Forstpolitik.

[b] In this and the following tables 40 cubic feet is a fair equivalent for 1 ton.

Percentage of imports from most important countries which export to Germany.[a]

Year average of—	Russia.	Austria-Hungary.	Sweden.	United States.	Norway.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1880-84	46.6	37.0	7.3	0.7	2.4
1885-87	40.8	34.6	8.1	.8	2.1
1888-96	47.4	33.4	10.9	2.4	1.6
1897-1901	37.8	42.1	10.6	5.9	1.2
1902	35.3	43.0	12.5	7.4	1.2
1903	37.5	41.1	10.6	7.5	1.0

[a] Endres, loc. cit.

Increase of exports, taking the period of 1880–1884 as a standard of 100.[a]

Year average of—	Russia.	Austria-Hungary.	Sweden.	United States.	Norway.
1880-1884	100	100	100	100	100
1885-1887	120	113	134	156	100
1888-1896	166	156	244	514	111
1897-1901	201	[a] 283	356	1,950	127
1902	180	245	350	2,000	109
1903	206	285	371	2,571	111

[a] Endres, loc. cit.

A glance at the above tables, with the knowledge that the forest resources of Germany are and have long been developed to their highest capacity, plainly indicates that Germany's imports will continue to rapidly increase. Her competition will be a large factor in bidding for any surplus timber in the future, and must not be lost sight of it in considering the possible sources of supply for the United States.

FRANCE.

A consideration of the following table shows that France will certainly continue to import, but the net imports are not appreciably increasing, since the population is about stationary, while the industries were already well established in 1875. The forest area is being extended, and coppice is being converted into high forest, so the imports will probably not increase to any extent for a number of years, but with growing industries they will certainly not decrease, and France will continue to be an important factor in competing for the surplus timber of the export countries.

Imports and exports of France.[a]

Year.	Imports.		Exports.		Excess of imports.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1875		$32,820,000		$8,280,000		$24,540,000
1880		55,600,000		6,960,000		48,640,000
1885		31,780,000		5,220,000		26,560,000
1890		31,580,000		8,580,000		23,000,000
1895		26,020,000		8,880,000		17,140,000
1900	1,658,000,000	35,400,000	1,123,000,000	9,920,000	535,000,000	25,480,000
1901	1,667,000,000	35,620,000	982,000,000	9,580,000	685,000,000	26,040,000
1902	1,584,000,000	33,820,000	935,000,000	9,320,000	649,000,000	24,500,000
1903	1,571,000,000	32,560,000	1,052,000,000	10,840,000	519,000,000	21,720,000
1904		33,480,000		10,780,000		22,700,000

[a] Endres, loc. cit.

France gets most of its sawn timber from Russia, Sweden, Norway, Austria, and America.

SWITZERLAND.

The following table shows that Switzerland, with its carefully managed and productive forests, is still increasing imports yearly with the development of industries, and must be reckoned with as a competitor in future bidding for timber.

Imports and exports of Switzerland.[a]

Year.	Imports.		Exports.		Excess of imports.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1878	180,000,000			$1,160,000		
1887	214,000,000					
1895	255,000,000	$2,580,000	54,000,000	380,000	201,000,000	$2,200,000
1900	273,000,000	3,160,000	64,000,000	520,000	209,000,000	2,640,000
1901	266,000,000	2,680,000	79,000,000	660,000	187,000,000	2,020,000
1902	278,000,000	2,840,000	77,000,000	640,000	201,000,000	2,200,000
1903	285,000,000	3,140,000	64,000,000	500,000	221,000,000	2,640,000

[a] Endres, loc. cit.

The percentage of firewood constitutes over half of the total import, most of which comes from southern Germany and France. The import of sawed material exceeds that of logs, most of which is imported from Austria-Hungary.

BELGIUM.

The net imports of Belgium are surprisingly large when the small area of the country is considered, and they are increasing at a rapid rate. In the future they will certainly continue to increase, and help swell the demand of western Europe for wood from foreign countries.

Imports and exports of Belgium.[a]

Year.	Imports.	Exports.	Excess of imports.
1870	$4,480,000	$520,000	$3,960,000
1880	11,600,000	2,200,000	9,400,000
1890	14,080,000	2,600,000	11,420,000
1896	18,300,000	....	....
1900	26,940,000	2,980,000	23,960,000
1901	26,520,000	2,800,000	23,720,000
1902	26,860,000	660,000	26,200,000
1903	[b] 27,980,000	580,000	27,400,000

[a] Endres, loc. cit.

[b] Represents 68,835,000 cubic feet.

Sweden is the chief source of imports; then come Russia, Germany, and France.

GREAT BRITAIN.

Great Britain, on account of its scarcity of forests, its highly developed industries, and its great coal production, imports more wood than any other country in the world. The English wood consumption has an influence on the lumber trade of the whole world, and also on the price of lumber; therefore the inevitable increase in it is of great interest to the United States, especially in view of the amount of imports from Canada.

Imports of Great Britain.[a]

Year.	Quantity.	Value.
	Cubic feet.	
1880	321,150,400	....
1890	300,236,500	$77,600,000
1900	496,247,400	125,464,000
1901	497,021,000	109,129,860
1902	498,516,400	122,156,960
1903	542,581,200	131,522,300
1904	458,900,000	....

[a] Endres, loc. cit.

The greatest imports are in sawed and hewed wood. Scandinavia furnishes one-third of the imports, Russia one-fourth, and America one-fifth. The export is practically nothing.

DENMARK AND NETHERLANDS.

These countries have such small areas in forest as compared with their population that imports of timber are certain to increase, as they have steadily done in the last few years.

ITALY.

The imports of Italy have slowly increased for some years, and the increase in population and development of industries will certainly more than offset any increased production of the forests, which are now mostly coppice and managed under a short rotation.

SPAIN, PORTUGAL, AND GREECE.

In spite of the fact that the industries of these countries are as yet scarcely developed, the forests can not supply the small consumption of wood. As mines and other industries are developed the imports must increase rapidly and help make the European deficit of timber much greater than at present, for the forest area per capita is extremely small.

TURKEY, BULGARIA, AND SERVIA.

These countries import timber in increasing amounts, although they are well wooded and industries are undeveloped. There is no question that their forest areas are sufficiently extensive to supply the home consumption were they under rational management and transportation facilities developed. But by the time these improvements are brought about, consumption will be much greater than at present, and the wasteful methods now in force will have greatly reduced the productive power of the forests. Considering the above facts, it seems safe to predict a continuation of the timber imports for some years at least.

EXPORT COUNTRIES.

EUROPE.

AUSTRIA-HUNGARY.

We come now to the exporting countries of Europe. Since the annual cut is greater than the annual growth, it is evident that the exports of Austria-Hungary must be reduced, for the forests are nearly all under careful management and their productivity can be increased only to a limited extent. As seen below the exports have steadily increased, and may continue to do so for some years, but not for long.

Wood export of Austria-Hungary.[a]

Year.	Exports.		Imports.		Excess of exports.	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
1880	1,746,000	$22,400,000	173,000	$1,150,000	1,573,000	$21,250,000
1885	2,258,000	31,600,000	223,000	1,750,000	2,035,000	29,850,000
1890	2,457,000	31,350,000	210,000	2,450,000	2,247,000	28,900,000
1895	2,398,000	32,850,000	156,000	1,850,000	2,242,000	31,000,000
1900	4,237,000	64,100,000	252,000	2,250,000	3,985,000	61,850,000
1901	3,903,000	55,650,000	268,000	2,200,000	3,635,000	53,450,000
1902	3,605,000	49,650,000	237,000	2,150,000	3,368,000	47,500,000
1903	4,238,000	58,700,000	267,000	2,300,000	....	....

[a] Endres, loc. cit.

Wood export of Austria-Hungary—Continued.

Year.	Exported to—				
	Germany.	Italy.	Russia.	Balkan countries.	Switzerland.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1885	33	14	6	17	2.7
1890	43	11	7	11	2.7
1895	50	18	10	10	2.1
1900	62	14	6	6	2.4
1901	60	16	9	7	2.4
1902	51	18	11	8	3.6
1903	54	17	10	....	2.9

RUSSIA.

The forests of Russia are capable of permanently producing much more timber than is now cut from them. In fact, the generally increasing deficit of wood in Europe must be met in large part from Russia. The following table shows how the exports of Russia have increased.

Russian exports to different countries.[a]

Year.	Tons.	Value.	Year.	Exported to—			
				England.	Germany.	Holland.	France.
				Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1885	....	$13,230,000	1894	50	24	9	8
1890	....	15,100,000	1895	46	28	8	8
1896	....	23,360,000	1897	40	35	10	7
1900	....	29,165,000	1900	41	32	12	7
1901	....	28,625,000	1901	43	30	12	7
1902	3,460,000	27,700,000					
1903	4,090,000	32,650,000					

[a] Endres, loc. cit.

Russia's imports are limited to the southern parts, and are mainly from Austria and Roumania. In 1901 the total imports were 756,600 tons, with a value of $4,560,000.

FINLAND.

Finland can no doubt increase her exports considerably, for the private forests cut but 0.2 of a cubic foot per acre more than the annual growth, while the 38.7 per cent of the forests which the State controls do not cut nearly so much as the growth. The following table shows the rapid development of the sawmill industry in recent years.

Development of the sawmill industry, by years.[a]

	1870.	1886.	1890.	1892.	1895.	1896.	1899.
Number of sawmills	132	245	341	376	427	464	460

[a] Endres, loc. cit.

In 1899, 248 sawmills were run by steam and 212 by water. Sixteen thousand workmen were employed.

Exports of Finland.[a]

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Cubic feet.			*Cubic feet.*	
1860	....	$1,920,000	1885	79,425,000	$7,880,000
1865	....	3,740,000	1895	122,491,000	12,200,000
1870	....	2,640,000	1901	164,851,000	20,300,000
1875	....	7,540,000	1902	168,381,000	21,620,000
1880	....	11,140,000	1903	211,800,000	26,200,000

[a] Endres, loc. cit.

SWEDEN.

Sweden's annual cut is less than the annual growth, and the forests may be expected to supply the home demands and allow the country to continue to increase exports to some extent. The following table shows the rate of increase in them of late years.

Exports of Sweden.[a]

Year average of—	Quantity.	Value.	Year average of—	Quantity.	Value.
	Cubic feet.			*Cubic feet.*	
1871-1875	116,490,000	$21,175,000	1897	246,750,000	$27,600,000
1876-1880	130,960,000	22,075,000	1898	236,160,000	36,600,000
1881-1885	161,670,000	24,125,000	1899	239,690,000	35,150,000
1886-1890	183,560,000	24,625,000	1900	245,690,000	38,450,000
1891-1895	210,040,000	28,275,000	1901	219,920,000	32,975,000
1896	235,800,000	32,975,000	1903	243,570,000	....

[a] Endres, loc. cit.

Great Britain takes about half of the Swedish exports, then come France, Denmark, Germany, Netherlands, Cape Colony, Australia, and South America. Planed boards go chiefly to Netherlands, Cape Colony, England, and Australia.

The large number of floatable streams in Sweden have been important factors in enabling it to take one of the foremost places in the world's timber market. The wood industry has been intensively developed. In 1898 there were 1,030 saw and planing mills, which employed 40,700 workmen; in addition there were 501 other woodworking establishments, with 22,300 workmen. As motor power, 507 turbines, 706 steam engines, and 178 electric motors were used.

NORWAY.

The forests of Norway are now being overcut, so that the exports, which have not increased much since 1870, will evidently decrease in the future.

Exports of Norway, by amounts and values.[a]

Year.	Quantity.	Value.
	Cubic feet.	
1870	67,211,000	....
1876-1880	64,964,000	....
1886-1890	65,517,000	$7,875,000
1895	59,128,000	6,900,000
1900	70,671,000	10,671,000
1901	63,717,000	8,900,000
1902	69,259,000	9,575,000
1903	75,260,000	11,125,000
1904	63,434,000	9,075,000

[a] Endres, loc. cit.

Exports of wood-pulp material are also very important, and in 1904 reached a value of $7,500,000.

The exports were distributed as follows:

Distribution of timber exports of Norway.[a]

Year.	South Africa.	Great Britain.	Belgium.	Nether-lands.	France	Germany.	Denmark.	Australia.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1881	....	64.0	2.8	10.0	10.0	4.5	4.3	....
1887	2.0	63.4	7.2	6.6	8.6	4.3	2.1	3.3
1898	2.5	57.0	9.0	9.0	5.0	5.0	....	7.0
1900	2.1	63.0	8.4	6.1	4.9	4.5	1.9	5.9
901	3.0	63.0	7.4	4.9	5.5	3.9	1.7	6.6

[a] Endres, loc. cit.

A little goes to Sweden, Iceland, Spain, and Brazil.

ROUMANIA.

Satisfactory data as to the cut and growth of forests in Roumania can not be had, but the forest area per capita is too small to expect much increase in export in the future, although of late years it has grown rapidly, as transportation developed.

SUMMARY FOR EUROPE.

The following table shows the great increase in the export timber trade of the world's leading export countries.

Value of export timber trade of leading export countries.[a]

Country.	Average of years—					
	1881-1890.	1891-1895.	1896-1900.	1901.	1902.	1903.
Sweden	$27,100,000	$31,450,000	$40,675,000	$37,250,000	$38,750,000	$41,500,000
Norway	9,350,000	7,850,000	11,325,000	10,000,000	10,750,000	14,000,000
Finland	8,700,000	10,175,000	17,500,000	20,300,000	21,625,000	26,250,000
Russia	16,925,000	22,700,000	29,250,000	30,900,000	29,925,000	35,250,000
Austria-Hungary	23,875,000	25,800,000	42,500,000	47,300,000	42,200,000	49,900,000
United States	21,375,000	21,250,000	40,300,000	41,375,000	52,075,000	51,550,000
Canada	23,000,000	23,450,000	27,850,000	29,850,000	33,500,000	31,400,000
Total	130,325,000	142,675,000	209,375,000	216,975,000	228,825,000	249,850,000

[a] Endres, loc. cit.

In 1903 the total import of Europe was 1,164,900,000 cubic feet,[a] and the total export 1,023,700,000 cubic feet, showing an excess import of 141,200,000 cubic feet.

This balance is made up chiefly from Canada and the United States.

A brief summary of Europe leads to the following conclusions:

1. The leading import countries, Great Britain, Germany, France, Belgium, Switzerland, etc., are rapidly increasing the amount of their imports, and this increase is certain to continue.

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[a] Endres, loc. cit.

2. Russia, Finland, and Sweden only of the export countries can increase to any great extent their export without reducing their timber capital.

3. Norway and Austria-Hungary are already overcutting, and will in all probability have to reduce their exports in the future.

In view of these facts, with the rising prices of timber, it is certain that any increased exports from Russia, Finland, and Sweden will be eagerly competed for by Great Britain, France, Germany, etc., and there will be no surplus of any consequence for the United States, handicapped as it is by greater distance, and hence greater cost for transportation. Hence in case of a failure of our timber resources, we must look to other than the European countries for a source of supply.

AFRICA.

EGYPT.

Egypt has no forests in the true sense of the word, but is interesting as a buyer. The industrial development and railroad building which the last few years have seen in Egypt, and which give every sign of continuing, will certainly result in increased demand for timber. The following table shows the important increase in it of late years.

Import of Egypt.

Year average.	Structural timber.	Firewood.	
		Quantity.	Value.
		Cubic feet.	
1885-1889	$1,547,000		
1890-1894	2,161,500	3,187,000	$220,000
1895	2,481,500	2,355,000	136,000
1896	2,122,000		
1897	2,506,500		
1898	3,170,500		
1899	3,213,500		

From A. A. Radzig, Forests and Forestry in Various Countries, A Statistical Investigation.

SOUTH AFRICA.

The forests of South Africa are entirely inadequate to supply home needs, and the imports are certain to continue to increase with the population and industrial development.

Imports of Cape Colony and Natal.[a]

Year.	Cape Colony.	Natal.
1890-1895	$575,500	$417,000
1895-1899	850,000	876 000

From A. A. Radzig, loc. cit.

These imports amount to 5,000,000 cubic feet, the annual average for the years 1895–1899. The following countries sent in 1895 to South Africa the amounts shown below:

Exports to South Africa.

Country.	Quantity.	Country.	Quantity.
	Cubic feet.		*Cubic feet.*
Sweden	2,465,777	India and Burma	56,679
Norway	1,041,[illegible]	New Zealand	32,548
United States	1,020,14[illegible]	South Africa	1,582
Great Britain	185,121		

From B. P. Mrozovski, Brief Review of Lumber Industry.

CENTRAL AFRICA.

The forests of Central Africa are little known, but their area is not so great as commonly supposed, and the chief species of commercial value are expensive hard woods, which have no bearing on the question of the supply of common timber for the United States.

NORTH AFRICA.

The countries of North Africa, other than Egypt, have barely sufficient forest for the low home consumption, except Algeria, which has already had to import timber. With increased railroad building and general development this import will increase.

Imports of Algiers.

Year average.	Value.
1890–1894	$813,500
1895–1899	814,000

From B. P. Mrozovski, Lumber Industry.

A review of Africa shows, then, a timber import destined to increase in the future in all but the central part, which is utterly undeveloped and can export only costly woods.

ASIA (EXCLUSIVE OF SIBERIA).

CHINA.

The reasons why China will continue to import in rapidly increasing amounts have been fully brought out; that it will take the surplus of eastern Siberia and continue to draw on the United States and Canada is certain.

Imports of structural timber of China.

Year average.	Value.	Year average.	Value.
1867–1870	$261,500	1885–1889	$744,000
1871–1875	440,500	1890–1894	1,074,500
1876–1879	616,500	1895–1899	1,201,000
1880–1884	592,000		

From B. P. Mrozovski, Lumber Industry.

PERSIA.

The forests of Persia are limited in extent and do not produce woods of common use to an extent to supply any timber for export.

CEYLON, STRAITS SETTLEMENTS, INDO-CHINA, ETC.

These minor countries of Asia are too little known and their forests are too little explored to give any basis for definite predictions. However, it may be said in a general way that they will not develop sufficiently for many years to import much structural timber and their exports are solely of valuable woods which are not important in this discussion.

BRITISH INDIA.

The exports of India consist of teak and other valuable woods, and it is found necessary to import structural timber. Thus India, while an export country from the point of view of value, is an import country if only common woods be considered, and will no doubt so continue, for any greater supply made available by better transportation facilities will be offset by greater consumption, following development of industries. The following table gives the exports of India for 1903-4, and shows the kind of forest products exported.

Exports of India, 1903-4.[a]

Material.	Quantity.	Value.
	Tons.	
Caoutchouc	90	$115,732
Lac	11,781	9,079,320
Sandal, ebony, and other ornamental woods		403,163
Cutch and gambier	5,652	657,904
Myrobolans	61,480	1,403,429
Teak timber	73,913	3,048,536
Cardamoms	128	112,538
Total		4,820,622

[a] Schlich, Forest Policy.

JAPAN.

Conflicting figures are given by different statisticians on the timber trade of Japan, according to how much they include under timber. If only structural timber is considered, Japan is an importing country by a small margin, while if all woods be considered it is an exporting country. Japan can supply home needs when all the forests are accessible, but will probably not be able to export any saw-log timber. Certainly this country can not look for any supplies from Japan, for any surplus will in all probability go to Manchuria, since the shorter distance and Japan's interest in developing that country would enable it to outbid the United States. The following table gives the exports and imports of wood and wood products, except match wood, in recent years.

Value of exports and imports of Japan.

	1892.	1896.	1900.	1901.	1902.	1903.	1904.
Export	$135,000	$460,000	$980,000	$655,000	$660,000	$980,000	$1,335,00
Import	40,000	145,000	450,000	355,000	380,000	335,000	255,00
Net exports	95,000	315,000	530,000	300,000	280,000	645,000	1,080,00

[a] Endres, loc. cit.

SUMMARY FOR ASIA.

A brief summary of Asia results in the following conclusions: (1) China and Australasia are import countries; the imports of the former will increase rapidly, while Australasia will probably not increase the amount of her import much; (2) Japan and India export valuable woods and import structural timber; (3) these countries will be buyers of saw-log timber, and can not be counted on as possible sources of supply for the United States, but must be regarded rather as possible competitors; (4) the Philippines, though now an importing country, should be able to export sufficient timber, when the wood industry is developed, to offset the imports.

AUSTRALASIA.

There is a difference of opinion as to whether poor condition resulting from abuse or inaccessibility is the cause of the insufficiency of Australasia's forests to supply home needs at present. In any case, the imports are sure to continue to increase for some years, and it is very unlikely that any surplus timber for export will ever be produced. The following table gives the net exports or imports of each of the colonies for the period 1894–1899:

Value of net exports and imports by colonies.

	Net exports.		Net imports.
Western Australia	$789,500	Victoria	$1,364,000
New Zealand	758,500	New South Wales	1,344,000
Tasmania	154,500	South Australia	1,003,500
Queensland	29,000		
Total	1,731,500	Total	3,711,500
		Total net exports	1,731,500
Net imports of all Australasia			1,980,000

From A. A. Radzig, loc. cit.

HAWAII.

Hawaii, with only about 1,175,000 acres of forest, and developing industries, can export only a trifling amount of timber.

THE PHILIPPINES.

The Philippine Islands contain about 49,000,000 acres of wooded land, and the estimate per acre given is 2,500 board feet, which gives a total of 122,500,000,000 board feet of merchantable timber. The Philippines import timber for two reasons—the inaccessibility of their own forests at present, and the need of light, easily worked wood. In time, as transportation is developed and the forests are made accessible, the native forests should supply nearly all the home consumption, and leave enough over for export to equal or surpass the quantity imported of certain classes of timber which are not found in the islands. But owing to the small amount of total stand, and the fact that there are only about 2 acres per capita in commercial forest, the increase in consumption with development of industries and increase in population will prevent the timber export from ever being an important factor in supplying the United States.

TROPICAL AND SOUTH AMERICA.

MEXICO, WEST INDIES, AND CENTRAL AMERICA.

These States now import timber not so much because they have none, but for the reason that it is at present inaccessible. Whether forest exploitation will develop as rapidly as other industries and the amount of imports remain stationary or be reduced or whether they will increase can not be safely predicted. It would seem that there will always be an export of mahogany, cedar, and other valuable woods, and it is most probable that there will continue to be an import of common woods.

SOUTH AMERICA.

For many years South America will continue to export hard woods, dyewoods, etc., and import lumber and construction material. Eventually, as the countries develop, the great forests now inaccessible will be opened up, and should supply home consumption, which will have increased greatly by that time. The imports will no doubt not increase to any serious extent, but are more likely to diminish. At the same time, the exports can not be counted on as a source of supply for this country for the reason above stated—that by the time the forests are accessible the country will have developed so much that home consumption will have greatly increased, and also because the forests are so situated that logging and transportation will be so costly as to prohibit the use of the wood for construction in this country.

NORTH AMERICA.

ALASKA.

Alaska has approximately 107,000,000 acres of forest land, of which 37,000,000 acres, situated along the south coast and the river valleys, bear relatively heavy forests of valuable species, while the remaining 70,000,000 occupy the interior to the limit of tree growth. The interior forest consists for the most part of scattered stands, and only from 50 to 75 per cent of it can be said to be actually forested. Estimating these stands to run 500 board feet to the acre, the interior forest contains not over 21,000,000,000 feet, board measure. This timber runs small and knotty, and is insufficient to supply the needs of the mining population, largely because much of it is inaccessible with the present means of transportation. With the increasing development of mines it is safe to assume that this interior forest will continue to be needed for local consumption and may fall short of supplying it. The forests of the south coast and of the river valleys, on the other hand, are often dense and the trees large. Toward the north the trees fall off in size and the forest gradually assumes the character of the northern forest. Estimating the average stand per acre at 2,000 feet, the total stand for this forest amounts to 75,000,000,000 feet, board measure, not quite twice the annual lumber cut of the United States. In this part of Alaska fisheries and oil developing are the principal industries, so that the home consumption of timber is not so great, and in all probability this region may in the future, when transportation is developed, be able to export timber to the United States. However, owing to the relatively small amount of forest, it can contribute but a very small part of the timber used by this country.

CANADA.

The Canadian forests are being cut and burned faster than they are growing, as shown in the first part of this article, and yet the exports are growing steadily, as shown below:

Yearly average and values of exports of Canada.[a]

1881–1890	$23,000,000
1891–1895	23,450,000
1896–1900	27,825,000
1901	29,850,000
1902	33,500,000
1903	31,400,000

In 1904 the value of wood imported was $9,000,000.

It is evident, then, that Canada, the only country which the United States can now count on for any considerable amount of timber, will not long remain a source of supply to the United States.

CONCLUSION.

The review of the timber trade of the various countries of the world shows a steady increase in wood consumption and imports of nearly all the leading import countries, and but three important countries, Russia, Finland, and Sweden, which can increase their export without lessening their forest capital. This increase will be needed in western Europe to make up the growing deficit there, and will not be a source of supply for the United States. Thus the tendency is toward a greater overcutting of timber on the part of the export countries, to make up the increasing deficit of the import countries, which policy, if continued, would lead to a universal shortage, with no surplus to draw upon. This picture, gloomy as it may seem, is offset by the birth of a new economic force—the general appreciation of the value of forests and the movement toward the introduction of rational forest management by all civilized peoples. There is no doubt whatever that there is enough accessible actual and potential forest land in civilized countries to produce, under proper management, an abundance of timber to supply indefinitely the world's growing demand.

Doctor Schlich states, in his Forest Policy, that by planting up waste lands in Great Britain, much of the annual import could be replaced by home-grown timber. If any material results can be expected in Great Britain, this country, with its great existing forests and large amount of permanent forest land, can certainly supply its timber needs. Not only of necessity, in view of the lack of any adequate foreign source of supply, but also from national pride and the desire to preserve a tremendous native industry, the United States should introduce rational forest management. At present, forest management would consist in large part of conservative treatment of existing forests with a relatively small amount of planting. If postponed until a timber shortage forces the United States to action, we should face the problem of the slow conversion of scrubby woodland into productive forest and the costly planting of denuded wastes on a very large scale. While the present area of wooded land in the United States is usually estimated as 545,000,000 acres, some of this is of no commercial value, and much is inevitably destined, with the increase in the population of the country, to be cleared for agriculture. The area of land so situated as to be permanent forest land is about 450,000,000 acres, of which 100,000,000 will consist of farm wood lots. The inevitable increase in wood consumption, following increase in population and growth of industries, will thus have to be supplied from a diminished forest area. Therefore the only solution of the problem of a wood supply is to begin now to prepare ourselves for making a diminished forest area supply an increased population. This means that the land should be surveyed and classified by the Government, and forest management applied to the permanent forest land now—before it is too late.

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[a] Endres, loc. cit.

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COST OF FORESTRY IN DIFFERENT COUNTRIES.

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A comparison of the expenses of forestry in different countries is necessarily unsatisfactory, because the forests differ in character and there is a very wide difference in economic conditions. In Europe systematic forest management was introduced many years ago. The forests are thoroughly organized, and the expenses of administration represent their maintenance, protection, and operation. In this country the work of forest organization has only just been started. Even our National Forests have only been roughly explored, and we have only estimates of the standing timber growing in them and its value. There are almost no roads, only a few satisfactory maps, insufficient demarcation of boundaries, very few fire lines, and the work of construction of headquarters, ranger cabins, telephone lines, etc., remains as yet to be carried out. Almost no working plans have been made for our National Forests, and the life history of the trees must be more completely studied before satisfactory methods of silviculture can be devised. Practically all of the work of organization of the forests remains to be done.

Other conditions enter in also to affect a comparison of expenses. In America and India there is great danger from fire, and large sums of money must be spent on providing adequate fire protection. In Europe, on the other hand, the danger from fire is very small in most places, largely because of a dense population, an enlightened public sentiment, and an organization of the forests which is the result of many years' work.

Again, the market conditions affect the kind of forestry which can be practiced. With constant good markets, as in Europe, it pays to use more intensive methods of forestry than where only certain classes of timber can be sold. For this reason the Germans can afford to spend on cultural operations proportionally larger sums than the Americans. In the same way the total expenses of forestry in a country are influenced by the methods of timber sales. If timber is sold on the stump the outlay is less than if the government does its own logging. The last system involves a large annual expense for logging which does not appear in the budget of a country which sells its timber standing.

These facts must be borne in mind in the study of the forest budgets of Germany, France, India, and the United States, which are discussed in the following pages.

A comparison of expenses in these different countries shows some astonishing differences. Prussia, with its forest of a little over 7,000,000 acres, spends each year about $14,000,000; India, with about 65,000,000 acres (including only reserved and protected forests), spends only about $4,000,000. The United States, with about 168,000,000 acres of national forests, spends only about $3,400,000. If these data are expressed in terms of the amount per acre, it is seen that the expenditure by Prussia is over $1.90 per acre as against that of the United States of about 2 cents per acre. In this connection it must be borne in mind, however, that Prussia did not expend so large a sum on forestry at the beginning of its work of organization. With the development of forestry and the increased demand for timber and the resulting high prices, it has been profitable to use more and more intensive methods and invest greater sums each year in forest cultivation. This is well illustrated in Prussia, which in 1849 spent for regularly recurring expenses about $2,000,000 each year, compared with $12,500,000 at the present time.

In other words, the expense of administration increases with the development of forestry. This is possible only when there are increased returns as a result of the increased initial expenses. This principle is illustrated in Prussia, where the net income has increased from less than $7,000,000 in 1848 to about $14,000,000 at the present time.

To carry out further the comparison of expenditures in the different countries, Prussia spends for salaries, including both administrative and executive forces, 52 cents per acre; France, 38 cents; India, a little over 2 cents; and the United States, a trifle over 1 cent. The average area in charge of a supervising forester in Prussia is about 10,000 acres; in the United States it is over 1,000,000 acres. While our western forests will not require a division into so large a number of administrative units as those of Prussia, the contrast is nevertheless exceedingly instructive.

Although the Prussian forests are already thoroughly organized, nevertheless the work of constructing and extending roads and bridges, dams, etc., is being pushed each year with an expense of over $500,000, and that is about the sum which is now being expended on all kinds of construction work in our national forests. In other words, for construction work, including buildings, telephone lines, etc., Prussia spends about 16 cents per acre and the United States about 3.5 mills. In reality the comparison ought to be reversed, for construction work constitutes an exceedingly important part of the first organization of a forest.

The great yield of timber and large returns in money from the European forests are the result of careful, intelligent forestry. Not only are the forests protected, but they are constantly improved; they are properly thinned to obtain the best possible conditions of growth, and open areas are planted with trees when reproduction can not be secured naturally. All of this involves expenditure of money. Such improvement work costs in Prussia $1,700,000 each year, or 23 cents per acre. Even in India there is an expenditure of over $173,000 a year for cultural operations. The expenditure in the United States is only about $50,000 for this item, a sum so small that it can hardly be expressed in terms of expense per acre.

One of the great problems in the United States is the training of men to handle the work of the national forests. At the present time the number of trained men available for the administration of the forests is entirely inadequate. The country is fortunate in having private schools which are educating men for federal service. The United States Forest Service is aiding these schools to a small extent, but the total amount expended is probably not over $1,000. This may be compared with $50,000 spent in Prussia, $37,000 in France, and $26,000 in India.

It is obvious from this brief comparison of expenses in different countries that the amount of money spent on the administration of the National Forests in this country is exceeding small, and it is perfectly obvious to anyone who knows the conditions that a very much larger amount is required to accomplish the purpose of the people of the United States in managing their government forests.

Expenditures for forestry in Prussia, France, India, and the United States.

PRUSSIA.

[From the budget of 1908.]

	Amount.	Per acre.
Recurring expenses:		
Superior staff	$1,433,590.00	$0.19
Subordinate staff	2,468,911.00	.33
Rents and expenses of offices	870,085.00	.12
Scientific work and education	96,750.00	.013
Extraction of forest products	3,082,750.00	.42
Cultural work	1,710,500.00	.23
Construction and maintenance of buildings	598,750.00	.08
Construction of roads, dams, etc	571,500.00	.08
Land purchase	262,500.00	.04
Administration of communal forests	492,000.00	.07
Other expenses	683,914.00	.09
Total	12,521,250.00	
Extraordinary expenses	1,149,450.00	.16
Grand total	13,670,700.00	
Average		1.823

FRANCE.

[From the budget of 1907.]

Recurring expenses:		
Superior service	$500,000.00	$0.17
Subordinate	614,000.00	.21
Service and expenses	145,400.00	.05
Education	37,200.00	.01
Cultural and protection	243,900.00	.08
Construction work	675,200.00	.23
Exploitation	83,000.00	.02
Hunt	15,200.00	.005
Special taxes	420,000.00	.15
Miscellaneous	52,400.00	.02
Total	2,876,300.00	
Average		.945

Expenditures for forestry in Prussia, France, India, and the United States—Con.

INDIA.

[Expenses for 1905-6.]

	Amount.	Per acre.
Recurring expenses:		
Superior staff	$774,884.00	$0.012
Exchange compensation allowance	28,083.00	.0004
Subordinate staff (including rangers, foresters, and guards)	704,218.00	.011
Office establishments (including contingencies)	347,171.00	.005
Extraction	1,478,176.00	.027
Roads and buildings	287,668.00	.004
Fire protection	192,596.00	.003
Cultural operations	172,763.00	.003
Live stock, stores, and plant	169,384.00	.002
Working plans	28,914.00	.0004
Rent for leased forests	285,979.00	.004
Miscellaneous	69,660.00	.001
Expenditure on realization of revenue from forests not managed by Government	7,121.00	....
Forest science and education (including all "A" and "B" charges of forest school)	26,656.00	.0004
Extraordinary expense	179,664.00	.003
Grand total	4,138,691.00	.0762
Average	....	....

UNITED STATES.

[Expenses for 1907-8.]

Administration (for the general administration of the Forest Service)	$162,703.38	....
Use (for the use, maintenance, and protection of the National Forests)	2,363,394.64	....
Improvements (for the construction and repair of permanent improvements upon the National Forests)	592,169.19	....
Studies (for studies necessary for the use and protection of the National Forests and of other forests in the United States, and to promote economy in the use of forest products and the distribution of their results)	297,840.40	....
Total	3,416,107.61	....

EXTENT TO WHICH FOREIGN METHODS OF FOREST ADMINISTRATION ARE SUITED TO CONDITIONS IN THE UNITED STATES.

By S. T. Dana,
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INTRODUCTION.

In the United States the science of forestry is still in the formative stage. Knowledge of the characteristics and requirements of the many species of trees composing the forests is limited; the total amount and distribution of forest wealth is not accurately known; and methods of administration are not as yet settled, but are subject to frequent change. In Europe, on the contrary, forestry as practiced to-day is the result of centuries of gradual evolution, and is consequently thoroughly systematized and its methods firmly established. While conditions in the United States differ materially in many respects from those in foreign countries, many of the general principles of forest administration are nevertheless of universal application, and the long experience of those countries in developing systems satisfactory to them may be of much value in establishing methods suited to conditions in the United States.

GERMANY.

Germany is generally acknowledged to have attained the greatest development in the practice of forestry, and is held up as a model of what may be accomplished by scientific management of the forests. There is scarcely a policy or a practice that has not been tried in that country, so that a knowledge of what has been found to yield the best results, and has been adopted as the permanent policy of the Empire, is of particular interest.

As in all other countries during the early stages of their development, the forests were at first neglected and abused. Not until the fear of a timber famine began to be felt was any effort made to protect or perpetuate them. As early as the fourteenth century, however, the supply of wood in certain localities had become so depleted that alarm for the future prompted the first attempts at forest protection. The earliest record of commercial planting is for 1368, when the city of Nuremberg successfully sowed several hundred acres to pine, spruce, and fir. These early attempts at forestry were local, however, and it was not until after 1500 that there was any systematic and general development of forest methods.

Following the close of the Middle Ages came a period of industrial development which, together with further settlement of the country, hastened the progress of forest destruction. With the danger of a general scarcity of timber confronting them the people were forced to devise some means of preventing waste and of securing a second crop. A beginning was accordingly made in all of the various branches of forestry, but it was not until within the last fifty to one hundred years that a settled policy of management became fully established.

It is interesting to note that in Germany the development of forestry was originally due almost entirely to fear of a timber famine and to the recognized necessity of taking immediate steps to maintain the wood supply. The necessity of preserving forests about the headwaters of streams in order to prevent and control floods and erosion was not one of the first causes leading to the forestry agitation, but this necessity is now clearly recognized, and protection forests are maintained at high altitudes throughout the mountainous districts, in which cutting is either wholly forbidden or is carefully restricted. This early neglect of the protective value of a forest cover was due largely to the fact that the greater part of Germany (75 per cent) is either level or hilly in character, and that the remaining mountainous portion was not heavily cut at first.

In Germany the fundamental principle of forestry, that the annual cut should equal the annual growth, has been clearly recognized. Accordingly, no attempt has been made to withhold the forest from use, but rather to regulate its use and to increase the amount available for cutting by increasing the annual growth through various cultural methods. This policy has been remarkably successful, as is evidenced by the fact that the annual growth for the Empire as a whole reaches the high average of 48.7 cubic feet per acre. This is in striking contrast to the United States, where the annual growth is estimated at about 12 cubic feet per acre. The excellent results obtained in Germany are due to the very intensive systems of management in use. These are made possible by the economic and industrial condition of the country. While 25.9 per cent of the total land area is covered with forest, this is well distributed and is everywhere broken by patches of cultivated land and by settlements. The forest area per inhabitant is only 0.61 acre as against more than 6 acres per inhabitant in the United States. The entire forest is therefore more or less readily accessible and open to utilization. Good roads exist throughout the forest and greatly facilitate transportation.

In money returns the German forests are still more strikingly in advance of the United States than in wood returns. In the state forests of Prussia in 1902 the gross receipts amounted to $3.20 and the net receipts to $1.66 per acre. Yet Prussia, although the largest, shows smaller returns than any other of the important States in the Empire. Wurttemberg, for example, in 1901 received from its state forests gross receipts amounting to $8.25 and net receipts amounting to $5.41 per acre. This is in contrast to the gross returns of $0.011 and the net returns of $0.005 per acre received from the National Forests in the United States in 1907–8. These much larger returns are made possible not only by the more intensive systems of management in Germany, but also by the excellent market conditions and high prices for wood. The demand for all forest products is so strong and so uniform that stump and fagot wood and even leaf litter can, in nearly all cases, be readily marketed. Waste is accordingly so far reduced that practically the whole tree is utilized, as against only 50 per cent or less in the United States. Wood prices are uniformly from three to five times higher in Germany, and there is often a still greater discrepancy between stumpage prices in the two countries. This, of course, greatly increases returns, and it is a well-known fact that where the highest prices prevail the practice of forestry has also reached its highest development.

The returns per acre from the forest bear a fairly uniform ratio to the amount spent on it, which is very interesting and worthy of note. Greater expenditures are in nearly every case followed by greater returns. Prussia, for example, spends less on its forests than any other of the larger German States and also receives smaller returns. In 1880 it spent $1.09 per acre on its state forests and received a net return of $0.92; in 1902 an expenditure of $1.54 brought a net return of $1.66. Baden in 1880 spent $2.17 and received a net return of $2.38 per acre; while in 1902 it spent $3.89 and received a net return of $5.08. In general the net returns per acre pretty closely approximate the expenditures, so that any increase in the amount expended on the forest means a corresponding increase in the receipts.

In developing the different systems of forest management, the Germans have been particularly favored in that the forest is comparatively simple in composition, with only a few species of great importance. This simplicity in composition, which has been still further increased by the methods of management employed, is in marked contrast to conditions in the United States, where there are a great many species of commercial value, and a very irregular and complex forest. This difference in the character of the forests makes the German methods of management, as a rule, inapplicable in the United States without modification. The general principles involved are, however, frequently of universal application and have already been successfully used in the United States; and the German experience is also of value in pointing out errors to be avoided.

The Germans have found conifers to be a more valuable crop and to produce a larger yield than hard woods. They were fortunate in having the conifers largely predominant in the original forest, and the tendency has been to increase their representation, until now the conifers form 65½ per cent of the total forest area and the hard woods only 34½ per cent. Forests grown from seed have also been found to be more profitable than sprout forests, and have consequently been encouraged. In the management of the forests in the United States these facts have not been generally recognized; coniferous forests have been cut over and abandoned to an inferior growth of hard woods, while hard wood stands have been allowed to exhaust themselves by repeated sprouting, with no attempt to secure seedling reproduction.

The intensive forestry practiced in Germany to-day is, of course, the result of a gradual development through many years of experiment, accompanied by frequent changes in methods and opinions. For a long time the methods used were entirely of empiric origin, and as always happens in such cases the development of satisfactory methods was consequently slow. In 1870, however, the need of thorough and systematic experiments as a basis for technical work was officially recognized, and a forest experiment station was established in Baden in connection with the Polytechnikum at Karlsruhe. Other States followed this example, and the policy has met with much favor and has been largely instrumental in the development of a more satisfactory forest practice than was possible before. This increased efficiency in technical work, as a result of the establishment of forest experiment stations, is of particular interest to the United States, where this method of carrying on investigative work has just been adopted.

In regard to the part taken by the State in forest management in Germany two facts of particular interest stand out prominently: (1) The State exercises at least a controlling interest in the majority of the forests, and (2) the forests under state ownership uniformly yield considerably larger returns than those under private or communal ownership.

In Germany the Empire, or central Government, takes no part whatever in the management of forests, which is left entirely to the individual States composing the Empire. These, however, do not correspond at all closely to the States of the United States of America, but are rather independent countries which are simply banded together for political purposes. State ownership in these States, therefore, corresponds quite closely to federal ownership in the United States. In Germany, as a whole, 31.9 per cent of the forests are under state ownership, while in the United States 26.1 per cent are under national and state ownership. In Germany, however, the State takes an important part in the management of both communal and private forests, and 66 per cent of the total forest area is actually under state control. The United States has no control over the 74 per cent under private ownership, so that there is a most decided contrast between the influence exercised by the Government in the management of the forests in the two countries.

The advantages of state ownership are clearly evident in the greater returns yielded under it. For Germany, as a whole, the state forests yield 58.5 cubic feet per acre, while the private forests yield only 39.8 cubic feet; communal forests are intermediate, with an annual yield of 53.1 cubic feet. This high yield is undoubtedly due to the strong influence which the state exercises in the management of the communal forests, all of which are subject in some degree to state supervision. This varies from merely restricting the clearing or selling of the forests to complete management of them by the state precisely as if they were state property. The stricter the supervision of the state the greater are the returns in almost every case.

Communal forests are a natural result of the development of property conditions in Germany and are a European institution which has no counterpart in this country. They are an important source of revenue to the community, sufficient in some cases not only to make taxation unnecessary, but even to yield a surplus to be divided among the citizens. Although circumstances have not led to the establishment of communal forests in the United States, there is apparently no good reason why they should not be established with equally satisfactory results.

In addition to exercising more or less control over the communal forests, the State retains the right to regulate the cutting of certain classes of private forests without regard to the wishes of the owners. For example, private forests can not be cut clear where they are considered necessary for the protection of watersheds or the prevention of torrents. This is in marked contrast to the treatment in the United

States, where the national and state governments have not in any way attempted to restrict private owners in the management of their forests. The recent decision of the supreme court of Maine, however, that the legislature has a constitutional right to pass laws regulating the cutting of timber on private land where the cutting is liable to be detrimental to the public welfare indicates that the very desirable oversight by the State of private management in cases of this sort may in time be secured also in the United States.

On one point the authority of the state in Germany is limited even in the management of its own forests. This is in the so-called "servitudes," or "rights of user," which custom has brought into existence and which give certain individuals the right to appropriate to their own use certain products of the forest, such as the fagot wood or litter. These in time became such a hindrance that in Bavaria in 1852 the establishment of new servitudes was positively forbidden. Other States had the same experience, and attempts were made to get rid of these servitudes, with such success that they have mostly been abolished or restricted so far as to be no longer impediments in forest management. The United States is fortunate in never having been burdened by such rights, and the experience of Germany is a warning against allowing them to develop.

In practically all of the German States the forest administration comes under either the department of agriculture or that of finance. The administrative machinery is more or less alike in all of the States, and Prussia, which is the largest, may be cited as representative. There the technical work of the forest service is divided into three distinct parts, under directing, inspecting, and executive officers. The work of direction lies with the central office, at the head of which is a technical man known as the "oberlandforstmeister," assisted by council of technical deputies, or "landforstmeister." This central office has entire charge of the forest policy of the administration, questions of personnel, approval of working plans, and direction of forest schools, and in all things pertaining to the forest service acts as a court of last resort. For purposes of practical administration the country is divided into several inspection districts, each under an "oberforstmeister," assisted by a number of "forstmeister." The power of these inspectors is not merely advisory, but they are virtually administrative officers in practical control of their particular districts. These districts are, however, still further subdivided into smaller districts, or working units, each under an executive officer known as an "oberforster," who is in charge of a number of "forster," on whom falls the actual administrative and executive work in the woods.

It is evident that this system is quite similar to the present organization of the Forest Service in the United States, where there is a central directing office with six separate administrative districts, all of which report to the central office. These districts are further subdivided into National Forests, which form the administrative units. The forest supervisor, therefore, corresponds to the German oberforster and the forest ranger to the forster.

While there is thus seen to be a striking similarity between the general systems of organization in the two countries, there is an equally striking difference between the sizes of the administrative units. In the United States the average size of a district under a supervisor is over 1,000,000 acres; in Prussia the average area under an oberforster is about 10,000 acres, and in the little Duchy of Saxe-Coburg it is only 2,000 acres. In the United States the average size of a district under a single ranger is over 100,000 acres; in Prussia the average size of the area under a forster is about 1,700 acres, while in the Grand Duchy of Baden it is only 750 acres. Evidently intensive forestry even approaching that of Germany will not be possible in the National Forests until the size of the working area is materially reduced. At present even adequate protection is impossible, and correct technical management of the forests still more so.

Another difference between the German and American systems of administration is the greater division of work in Germany. There the technical, constructive, fiscal, legal, and police work necessary in forest administration are usually kept distinct; in this country the technical, constructive, and police work not infrequently have to be done by the same men. The result is that all three lines of work more or less interfere with each other, with consequent loss of efficiency.

In the matter of technical forest education, the German Government exercises a more direct influence than does the United States Government. In Germany the technical forest schools are conducted directly by the State, while in the United States the forest schools are all connected with private or state institutions. The Federal Government has no direct control over any of them. It has recently, however, made arrangements for giving instruction to rangers in cooperation with private institutions, and to this extent is following the lead of Germany, where ranger schools are well established. The Germans insist on a more thorough technical training for all of their forest officers than is required here, and no one is put in charge of technical forest work who has not had a thorough technical training.

In the dissemination of popular information concerning forestry the United States compares favorably with Germany. All available information of value is published promptly in the form of readable circulars, and the Government assists in educational work by furnishing speakers, by lending lantern slides, and by outlining methods of instruction.

FRANCE.

While France has not yet succeeded in developing such intensive forest methods as Germany, it has nevertheless clearly recognized the necessity for conservation of its timber resources, and its experience in reforestation is of particular interest to this country. By the middle of the seventeenth century the progress of forest destruction had reached such a point that Louis XIV's great minister, Colbert, remarked, "France will perish for lack of woods." The forest ordinance of 1669, which was passed through his influence, was a great step toward forest regulation, and, with the exception of the years during the French revolution, continued in force until the passage, in 1827, of the Code Forestier, which, with certain revisions, is the law of the present day. It is thus seen that while France early recognized the necessity of preserving its forests, the development of a satisfactory forest policy was comparatively slow.

The growing scarcity of timber was the cause of the first steps toward forestry, although the necessity of preserving the forests for the protection of watersheds and the water supply had a much earlier and much stronger influence than in Germany. As early as the sixteenth century the local parliaments enacted decrees against clearing in the mountains, but during the revolutionary period these restrictions vanished, the mountains were stripped of their forest cover, and tremendous damage resulted. The first work of recovery was begun in 1843, but owing to political events did not progress very rapidly until 1860, when the passage of a special law charged the forest department with the mission of extinguishing the floods. In 1882 this act was amended, so as to place the entire cost of the work on the State. Out of the 1,462 brooks and mountain streams which are considered dangerous in the Alps, Pyrenees, and Cevennes, 163 had in 1893 been entirely controlled, and 654 had begun to be "cured." Among the former were 31, the control of which fifty years ago was considered by engineers to be impossible. This probably furnishes the best practical example of the disastrous effects which follow deforestation in the high mountains and of the possibility of controlling torrents by afforestation.

In France the total forest area covers only 18.2 per cent of the total land area, and the forest area per inhabitant is 0.61 acre, precisely the same as for Germany. Although the annual consumption is only 24.6 cubic feet per inhabitant the supply is insufficient, and France is, next to England and Germany, the largest wood-importing country in Europe. This deficiency in the timber supply has not led to overcutting, however, and France, like Germany, has clearly recognized the fundamental principle that the annual cut must not exceed the annual growth. This in France is 37.9 cubic feet per acre, which, although high in comparison with the growth in the United States, is rather low compared with that in Germany. This is due partly to the less intensive management practiced in France and partly to the composition and character of the forest. Of the total forest area only 20 per cent is stocked with conifers, while 80 per cent is stocked with hard-wood stands, many of which are of sprout origin. Efforts are now being made to better the forest by converting sprout stands into seedling stands and by increasing the percentage of conifers.

In the development of a silvicultural practice the French have made considerable advance, but have not attained the perfection reached in Germany. An unfortunate tendency has been to stick to one system of cutting, regardless of conditions, and to make arbitrary marking rules. The result has been to deprive the local forest officers of any spirit of initiative and to force the adoption of certain set methods regardless of their applicability. The methods used were wholly of empiric origin until the necessity of introducing experimental methods was recognized by the establishment in 1882 of a forest experiment station at Nancy.

The greatest advances in forestry made by the French have been in developing new ideas regarding thinnings and in the work of reforestation. During the last century over 2,500,000 acres have been reforested, mainly in the mountains and in the sand dunes, marshes, and limestone wastes. The sand dunes along the coast of France, chiefly in Gascony, were formerly covered with forests, but by the destruction of these were turned into barren wastes. As early as 1717 small attempts at reforestation were made, but work was not taken up on a large scale until the last century, since which time 275,000 acres of moving sand have been fixed by plantations of pine. East of the dunes stretch the Landes, an area containing 2,000,000 acres of shifting sands and marshes. From 1850 to 1892, 1,750,000 acres of these were drained and successfully planted to pine at a cost of from $4 to $5 per acre, and a recent estimate places the value of this territory at $100,000,000. Between the valleys of the Loire and the Cher lies the region of La Sologne, a sandy, poorly drained plain upon an impenetrable calcareous subsoil. This region was originally densely wooded, but by 1787, 1,250,000 acres had become absolutely abandoned as a result of deforestation. Over 200,000 acres of nonagricultural lands have now been reclaimed by plantations of Scotch and mountain pine. Lands which fifty years ago could hardly be sold for $4 per acre now bring an annual revenue of over $3. In the province of Champagne 200,000 acres of arid limestone wastes have been reforested, mainly with pine, and now yield a net revenue of $2 per acre. The successful attempts at reforestation and controlling the torrents in the mountains have already been mentioned.

The results obtained in France along these lines are of special interest to the United States, where there is also much waste and deforested land which will never be valuable except for forest purposes, and which requires planting to restore the forest cover. France has proved that even arid wastes can be successfully planted and made to yield a net revenue.

The money returns from French forests resemble the wood returns in being less than is the case in Germany. In 1902 the state forests of France yielded a gross revenue of $2.45 and a net revenue of $1.47 per acre. A striking fact in this connection is that the present yield is actually slightly less than it was forty or fifty years ago. This is probably due to the fact that the condition of the forests has not improved materially during that time, and particularly to the fact that the forests are now largely composed of broadleaf species which, since they are to a great extent in poor condition, yield an abnormally low percentage of saw timber. The yield is, nevertheless, in striking contrast to the net returns of $0.005 per acre in the United States, where the species are, as a rule, both more valuable and more rapid growing. This is due partly to the higher prices and better market conditions, but far more to the greater care bestowed upon the forest. The expenditures equal about one-half the gross receipts, and, as in Germany, both the gross and net receipts show a noticeable increase with increase of expenditures. Although the forest has been under administration for many years, nearly 25 per cent of the total expenditures is still devoted to permanent improvements. In the United States, on the other hand, permanent improvements, which are essential to the proper administration of the forests, receive less than 5 per cent of the total expenditures.

As in all European countries, the State takes an important part in the management of the forests. Only 12 per cent of the forests is under state ownership, but the State also exercises a controlling influence over all of the communal and many of the private forests. In general, the state and communal forests show better returns than those under private management. The State exercises an even greater control over the communal forests than in Germany. Private owners, however, are free to manage their forests as they please, except in the case of protection forests necessary to prevent erosion, to maintain the water supply, or prevent the drifting of sand in dunes along the coast, or for the benefit of the public health. In all of these cases the State reserves the right to prevent the clearing of the forest and to prescribe the system of cutting. The State encourages cooperation with private owners, and is ready to undertake the management of private forests when requested to do so by the owners.

Much trouble has been experienced in the management of the state forests by the existence of rights of user, similar to those in Germany. These proved to be such a hindrance that in 1827, on the passage of the Code Forestier, a systematic plan was made to extinguish them, and the work may now be considered practically complete.

The administration of the state forests is under the minister of agriculture as president of the forestry council, with the director-general as vice-president and technical head. The central office also comprises three administrateurs verificateurs généraux, as chiefs of the three bureaux into which the administration is divided, each with two chiefs of sections, inspectors, and the necessary office staff. For purposes of local administration the forest area is divided into 32 districts, each under the charge of a conservateur, who corresponds to the German oberforstmeister. These are again subdivided into a number of cheffries, or inspections, which are administrative units, under inspectors and assistant inspectors, corresponding to the oberforster in Germany and to the supervisor in the United States. The actual forest work is done by gardes généraux, with the assistance of gardes généraux stagiaires, corresponding to the German forster and to the American rangers. These officials comprise the superior service, which is kept very distinct from the inferior service, composed of underforesters (brigadiers), or guards, and other workmen, corresponding to enlisted men in the army. The system evidently corresponds quite closely to both the German and American systems of administration.

France has only one forest school where higher technical education can be obtained. This school was established by the State in 1825 at Nancy, and in spite of various unfortunate experiences, has continued to the present day. It is intended primarily for the training of state foresters, and only 12 students are allowed to graduate annually, although foreigners and others who are not seeking state employment may study there. At Barres the State maintains two lower grade schools, one of secondary and one of primary instruction, for the training of forest guards. The superior service is composed of technically trained men, although these officials are not as a rule so thoroughly educated as in Germany. The opportunities for forest education in the United States and the part taken by the Government in spreading general information concerning forestry to the public compare favorably with France.

SWITZERLAND.

Switzerland is of interest because it is a republic, somewhat similar in form to the United States; because it shows intensive forest management, with high returns; and because it has developed an efficient system for the protection of its mountain forests.

The forest area occupies 21.2 per cent of the total land area. The forests are very irregularly distributed in the different cantons, but are present everywhere in the high mountains. A striking fact concerning them is the great number which are under communal ownership. Sixty-six and nine-tenths per cent are owned by communes and corporations, 28.8 per cent by private individuals, and only 4.3 per cent by the cantons, or States; the Bund, or Federal Government, does not share in the ownership of any of the forests, although it does take an important part in their management.

The forests are separated into protection and nonprotection forests, the former being such as are located at headwaters of streams or furnish protection against snowslides, landslides, floods, or climatic damage. All protection forests, whether public or private, are under federal surveillance, and must be surveyed and their bounds permanently marked. Their management is so regulated as to secure a sustained yield according to working plans sanctioned by the Federal Government; fellings must be made under the direct supervision of a trained forester, and clearing the forests is prohibited except by permission of the Federal Government.

All communal forests are subject to general supervision by the cantons. In nonprotective private forests the owner is free to manage his property as he pleases, with certain restrictions. Clearing is prohibited except by permission of the cantonal government; felling areas must be reforested within three years, and existing pasture woods must be maintained. Wherever protective forest areas can be created by the reforestation of waste land, this may be ordered, and either the Federal or the cantonal government contributes toward the expense of the reforestation. The law encourages the cooperative forest management of small holdings, the Bund paying for the cost of effecting such cooperation; it also empowers the Bund or the canton to enforce such cooperative management in specially endangered localities, as at the headwaters of torrential streams. This system of cooperation has been very successful, and the general system of federal supervision has met with excellent results. Torrents have been checked and controlled, and excellent financial results have been obtained. Planting has been resorted to in order to extend the forest area, particularly in the mountains, and the forest area has actually been increased 10 per cent in the last fifteen years.

For Switzerland as a whole the annual growth reaches the high average of about 51 cubic feet per acre. This also equals the annual cut, since Switzerland, in common with France and Germany, cuts only the annual growth. As usual, the state forests show the highest yields. During the four years prior to 1893 the average cut of the state forests was over 64 cubic feet per acre, while that of the corporation forests was only 42 cubic feet.

The money returns vary widely, averaging for most of the cantonal and communal forests between $3 and $9 per acre. In 1903 the net receipts of the town forest of Winterthur reached $11.69 per acre. The Swiss forests are thus seen to yield exceptionally high returns, partly on account of good prices and ready markets and partly on account of highly developed silvicultural practices. From 1895 to 1899 the average stumpage price for both timber and firewood was 6.3 cents per cubic foot—about the same as in Prussia. In the low country, however, wood prices are higher than the average in Germany, and coniferous saw material brings prices of from 12 to 15 cents per cubic foot.

Silvicultural practices are well developed and nearly all of the forests are managed under working plans. The Federal Government in 1855 instituted a two-year course in connection with the Polytechnikum at Zurich for the education of the higher forest officials, and in 1884 the course was increased to three years. In connection with the school at Zurich is a central forest experiment station, with several substations, where thorough scientific investigations of practical problems are pursued, the results of which have proved of great value in forest management. The cantons also give short courses for the education of the lower-grade foresters.

Switzerland repeats the history of other countries in having done but little for the preservation of its forests until forced to do so by circumstances. The first working plan seems to have been made for the Sihlwald, the city forest of Zurich, in 1680–1697; and the Bernese cantonal forests were first surveyed and placed under management from 1725 to 1739, and were fully regulated by 1765. These first efforts at establishing a forest practice were not general, however, although by the beginning of the eighteenth century the growing scarcity and increasing value of forest products had called attention to the necessity of protective measures.

Fears of a timber famine had previously caused a number of cantons to attempt to prevent further decrease of the forest area, but not until the severe flood of 1830 emphasized the protective value of a forest cover were these ordinances strictly enforced and a general movement for the better begun. The increase in torrential floods hastened the movement, and resulted in the delegation to the Federal Government of power to regulate the use of the protective forests. Forestry in Switzerland, then, was at first a result of the growing scarcity of timber, but did not develop rapidly until the severe floods resulting from the destruction of protection forests in the mountains forced the necessity of their preservation on the people. Rapid strides have since been made, and Switzerland has succeeded in proving beyond question that forestry can be profitably conducted, and that the use of protection forests can be satisfactorily superintended so as to maintain their productive capacity without lessening their protective value.

AUSTRIA.

Austria is of particular interest because forest conditions more closely approximate those in the United States than do those in any other of the countries considered. Austria shows variable forest conditions in different parts of the country, with considerable areas of virgin forest in the mountains; private ownership is more extensive than elsewhere in Europe, and the state forests are only now being thoroughly organized.

The forest covers 32.5 per cent of the total land area, with 0.91 acre of forest land per inhabitant. This large forest area enables Austria to be one of the few wood-exporting countries of Europe. This export is largely at the expense of the forest capital, however, since the annual cut varies from 60 to 67 cubic feet per acre, while the annual growth is only 42.4 cubic feet. This high yield for a country which is relatively undeveloped as compared with Germany, France, and Switzerland, is due partly to the fact that the forest is composed mainly of conifers (82 per cent), and partly to the fact that rapid strides have been made toward conservative forest management within the last fifty years.

In the northwest provinces, such as Bohemia, Moravia, and Silesia, where the population was denser than elsewhere, and where the influence of Germany was most strongly felt, the forests were early taken care of and forest management well developed. German methods were largely followed, and in some places almost model forests were in existence as early as 1848. In the more inaccessible mountain districts, however, the forests were for a long time neglected, and it is only within the last fifty years that material progress has been made in bringing them under management.

The state forests comprise only 7.3 per cent of the total forest area, and lie mainly in the more remote mountain districts. Twenty-six per cent lies in the plains and foothills, 49 per cent at medium elevations in the mountains, and 25 per cent in the highest mountain region up to the limit of tree growth. This region is largely undeveloped and inaccessible, so that for twenty years from 1874 to 1893 the annual net returns amounted to only 26.8 cents per acre. This is in striking contrast to the high returns in the more thickly settled European countries to the north and west. It is also in equally striking contrast to the net returns of 0.5 cent from the National Forests in the United States, where conditions are somewhat similar to those in Austria. Working plans have been prepared for most of the state forests, and by 1898 nearly 82 per cent of them were under regulated management. The silvicultural systems employed are largely based on those in use in Germany. They are, however, less intensive, are better adapted to the sparsely populated mountain districts in which most of the state forests lie, and are therefore more applicable to conditions in the United States.

One of the most difficult problems which the State has had to solve is the reforestation of the "Karst," a dry limestone waste lying in the mountain and hill country of Istria, Trieste, Dalmatia, Montenegro, and adjacent territory skirting the Adriatic Sea. This area was originally well forested with conifers and hard woods, but through reckless cutting, burning, and pasturing was reduced to a barren waste. Attempts to reforest it have not been wholly successful, and much remains to be done. A small portion of it has been planted and a considerable area reforested by protective measures, particularly by the exclusion of goats. Enough has been done to prove that the waste can be restored to its original forested condition, although at the expense of much time and money.

The private and communal forests are not so well managed as those belonging to the State, but great improvement has been shown in their management in the last twenty-five years, and more and more of them are being brought under the regulation of approved working plans. According to the general rule in Europe, all protection forests, including those under private ownership, are under state supervision, and cutting in them is carefully restricted. No forest can be absolutely cleared away without permission, and private owners may be compelled to restock blanks in their forests if these have a protective value. A unique feature of the relation between the State and private owners lies in the so-called "forest protective service." The severe floods of 1851 called attention forcibly to the necessity of forest protection, and an organization was created to manage the state forests, supervise the management of corporation forests, and afford police protection to both. In 1883 the functions of this service were extended "to instruct and encourage forest owners in forest culture, and to manage forests so designated to be managed." This service has proved so satisfactory that owners have freely availed themselves of it, and now ask constantly for its extension. It has succeeded in bringing about extensive cooperation with private owners, and about 60 per cent of the Austrian forests are now managed under working plans.

The organization of the state forest administration is much as in Prussia. The forest service is in the department of agriculture, with an oberlandforstmeister at its head. The country is divided into a number of inspection districts in charge of oberforstmeister and forstmeister. These are further subdivided into working areas under oberforster, with the assistance of "forstwarte" as executive officers. The average size of a district under an oberforster is 452,762 acres, which corresponds more closely to the size of an area under a supervisor in this country, although still but half as large. There is a more marked contrast in the area under the management of a single local officer. The average size for this in Austria is 13,880 acres, as against more than 100,000 acres under a single ranger in the United States.

There are a number of forest schools in Austria for the training of both of the higher and the lower grades, and an excellent state school at Vienna. There are also a number of forest experiment stations in the country, which have done much for the advancement of forestry.

CONCLUSIONS.

This brief review of foreign methods of administration brings clearly to light certain facts which can well be used in developing methods of forest administration in this country, and which it may be well to summarize here.

The experience of foreign countries has invariably proved that evil results follow if the forest is neglected and recklessly exploited until its preservation and protection is made absolutely necessary by fear of an impending timber famine or by disastrous floods. Many years and great expense are required to restore the forest to its normal productive capacity, whereas this capacity might have been greatly increased at much less expense of time and money if steps had been taken early enough.

The Europeans have also proved not only that forestry is necessary if the forests are to yield the best results, but also that it is profitable. The more intensive the forestry practiced the greater, as a rule, are both the wood and the money returns. The more that is spent upon the forest per acre the greater are the net returns received from it. Economic conditions in this country at present do not permit in many places of as intensive methods as are possible in Europe. The principles involved are applicable at once, however. Measures for forest preservation should be taken before it is too late; waste should be reduced to a minimum, more money should be spent on the forest in order to increase net returns, and above all the annual cut should be limited to the annual growth in order not to deplete the forest capital.

Foreign silvicultural methods are not usually applicable without change, but the general systems have been adapted with success to conditions in this country, and should be still more widely used. The important point to be recognized in avoiding the mistakes made abroad is that hard and fast, arbitrary rules seldom yield good results, and that the system adopted must be elastic and adapted to specific conditions. France, in particular, has proved that barren wastes and denuded mountain slopes can be successfully reforested, and this system of reforestation is as applicable in this country as there. Wholly empiric methods of forest management have invariably failed to yield the best results, which can be obtained only by systems based on carefully conducted experiments and thorough research work. Forest experiment stations are, therefore, a necessity if forestry is to reach its highest development.

A striking point concerning forestry abroad is the important part taken by the State in the management of communal and private as well as of state forests, and the considerably greater returns obtained under state management. All communal forests are subject to some form of state supervision, and many of them are managed precisely as if they were state property. Private forests necessary for the protection of watersheds or the welfare of the general public are also subject to state control; they can not be cleared, cutting must be done as prescribed by the State, and all cuttings must be reforested. Other private forests not necessary for protective purposes can usually be managed as the owner desires, but cooperation with the State in the management of such forests is common, so that the State also exercises a large influence in the management of private forests. State management is the most stable and efficient, and almost invariably yields the best results. There is apparently no sufficient reason why this should not also be the case in the United States. Government supervision of protection forests, where necessary for the welfare of the public, can hardly be considered as unwarranted encroachment on private rights, and might well be adopted here. More extensive cooperation between private owners and the Government in the management of other private forests would also undoubtedly yield good results and should be encouraged as much as possible. Communal forests have arisen in Europe as a result of the economic development of the country, but they have given such excellent results there and have proved so profitable that it would seem as if similar town and city forests could be advantageously established in the United States.

In general the organization of the Forest Service for the administration of the National Forests in the United States is similar to that in most European countries. The most noticeable differences lie in the much greater area under the administration of a single executive officer in the United States and in the lack of technical training in many of the men engaged in technical work. The forests can never be properly protected nor cared for until the working areas are so reduced in size that a man can adequately care for his district, and until a thorough technical training is required of men engaged in technical forest work.

At present the results of forest administration in the United States do not compare favorably with those attained in Europe. This is largely due to economic conditions, which have made impossible the development of very intensive forest practices, and to the lack of public interest in forestry and failure to realize its necessity and practicability. There is no good reason why this should continue, and no reason why the United States should not secure in time fully as good results as are now obtained in Europe. Forestry in this country is still young and time is necessary for its development; but this development can be hastened and guided by using the experience of European countries and by adopting, so far as conditions warrant, those methods of administration which have proved successful there.

FOREST FIRES.

By Clyde Leavitt,
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SUMMARY.

Fire is the greatest enemy of the forest. The lack of reliable statistics is the greatest obstacle to the securing of effective measures for fire prevention and control.

DAMAGE FROM FOREST FIRES.

More than 2,000 people perished in forest fires in the United States in the nineteenth century. During the past thirty-seven years there has been an annual average of 50 deaths from this cause.

The value of the standing timber destroyed has varied from $25,000,000 to more than $100,000,000. The direct annual loss has averaged $50,000,000.

The destruction of the young growth, though never included in estimates of fire damage, is a principal item of loss. The natural restocking of burned-over lands takes place very slowly or not at all. Had fires been prevented on nonagricultural lands now unproductive because of forest fires, 32,000,000,000 feet of timber, valued at $64,000,000, would now be produced annually on this land. The amount of this loss is equivalent to 80 per cent of the total lumber cut of the United States, or 32 per cent of the total consumption of wood material of all kinds.

Not less than 20,000,000 acres of young growth are burned over annually. At $10 per acre, the cost to replant is $200,000,000. Repeated fires have totally destroyed the forest over immense areas of nonagricultural lands and rendered the restoration of forest conditions possible only by artificial planting at great expense. Even where the forest has not been destroyed, its composition over immense areas has been changed for the worse.

In mountainous regions, deterioration and erosion of the soil, due to forest fires, cause a loss that is in many cases greater than that resulting from the destruction of the stand of merchantable timber and of young growth.

The destruction of the forest by fire results directly in an impairment of the regularity of stream-flow, tending to cause an alternation of flood and drought. Thus are brought about great losses to irrigation, water power, navigation, and other interests.

Fires, by reducing the available supply of raw forest material, have increased the cost of all forms of forest products.

The forest, if properly protected, is a reproducible resource; to be treated as a crop, differing from ordinary farm crops only in the time element. Under present conditions, the forest is exhausted, like the mine. The lumber industry is nowhere on a permanent basis, but has moved steadily West or South. This is true also of the naval-stores industry.

The power of the community for development through taxation is decreased by forest fires, since taxable property of great value is destroyed. This in turn is reflected in a general lowering in the values of all remaining forms of property.

CAUSES OF FOREST FIRES.

The principal causes of forest fires in the West are railroad locomotives, campers, and lightning. In the East and Middle West the principal sources of danger are the clearing of land and sparks from railroad locomotives. In the South practically all the forest fires are set intentionally, the greater part of the forest area being burned over annually.

In general, the great majority of fires are due to carelessness and ignorance.

FIRE PREVENTION AND CONTROL.

Damage by forest fires is practically preventable. In the United States, however, the people as a whole have never realized that fire protection is sufficiently desirable to make it worth while, or that it is practicable as a sound business measure.

Preventive measures are (1) administrative; (2) legislative; (3) educative. The aim of the second and third is to secure adoption of the first.

Of administrative measures, the most effective are patrol, brush burning, fire lines, back firing, the construction of roads, trails, and telephone lines, and the use of lookout and observation towers. Of these the one most vitally essential is patrol.

Legislative measures have in general been inadequate on account of lack of enforcement. A strict enforcement of existing laws would go far toward removing ignorance and indifference.

The present tendency toward replacement of coal by the use of electricity or petroleum as motive power on railroads traversing forest lands offers the greatest encouragement for the future.

Educative measures are of primary importance, because it is through them that the adoption of administrative and legislative measures is secured. The most effective is the dissemination of information concerning the causes and effects of forest fires and the methods by which they may be prevented or controlled.

RESULTS ACCOMPLISHED BY THE FEDERAL GOVERNMENT.

The national forests, though undermanned, offer the best example in the United States of an efficient system of fire prevention and control. In 1904 the area burned over was 0.66 of 1 per cent of the total area of the forests, exclusive of Alaska and Porto Rico; in 1905, 0.31 per cent; in 1906, it was 0.094 per cent; and in 1907, 0.14

per cent. The value of merchantable timber destroyed in 1907 was only 40 per cent of that burned the preceding year. The merchantable forest burned over in 1907 represented but 0.02 of 1 per cent of the national forest area.

The Forest Service cooperates with States and counties and with private owners and railroad companies for better fire protection on the national forests and on areas adjacent, the burning over of which would be a menace to the forest property of the Government.

On military reservations and national parks damage by fire is reduced almost to a minimum on account of the presence of federal troops. On Indian reservations until very recently practically no steps have been taken to prevent the occurrence of fires or to control them after starting. As a result there has been immense loss. On the public domain no steps whatever are taken to prevent or control forest fires.

RESULTS ACCOMPLISHED BY STATE GOVERNMENTS.

The action taken by States has been altogether inadequate. The best results have been accomplished in New York, New Jersey, Pennsylvania, Wisconsin, and Minnesota. More state forests should be created, and protected and administered at state expense.

RESULTS ACCOMPLISHED BY PRIVATE OWNERS.

On probably not more than one per cent of the 450,000,000 acres of forest lands in private ownership in the United States is there a system of fire protection in which the object sought, and for the most part accomplished, is the prevention of fires rather than the mere control after the fires have actually begun.

INTRODUCTION.

Of all the enemies of the forest, fire has without exception been the most destructive and far-reaching in its effects. Forest fires have occurred since the earliest periods of which we can gain any record. That disastrous fires were started by natural causes in the earliest history of the country can not be questioned. That with the advent of man the damage has vastly increased is equally true. Without adequate protective measures there is no question that the risk from fire on forest land would continue to be greater, year after year, as the country is opened up by railroads, and clearings are made by settlers, and as timber is cut by the logger. All experience goes to prove that fire follows the railroad, the settler, and the lumberman. Occasionally large forest fires occur which assume the proportions of national disasters, and public sympathy is temporarily aroused for the immediate sufferers. Such a fire was the one which occurred during the first days of August, 1908, in the mountains south and southeast of Fernie, British Columbia. The death loss from this fire was 18 people and the value of timber and other property destroyed was more than $6,000,000, and 6,000 people were made homeless.

Fire had been reported as burning on cut-over lands near Fernie for some time previous to the disaster, but until a heavy wind sprang up and caused the rapid spread of the flames no attention was paid to it and no attempt made to extinguish it. According to the newspaper report, it was commonly supposed that "the fires were doing no damage." This state of mind is typical of what has long been the attitude of the great majority of the American public toward the fire problem. Some progress has been made toward overcoming this point of view, but the results, as expressed in concrete form, have been pitifully inadequate. The damage from forest fires in the United States amounts annually to many million dollars and occurs in many different forms. The greatest obstacle to securing the adoption of adequate measures for the prevention and control of forest fires has been the almost total lack of reliable statistics of fire loss. It can hardly be conceived that remedial measures could long be delayed were the people as a whole fully informed of the incalculable economic loss that is being sustained each year from this source, and of the beneficial results that could be obtained by the expenditure of comparatively small sums in protection. For only a very small percentage of the forest fires that have occurred, even in recent years, has any attempt at an estimate been made.

Outside of the loss of buildings and personal property, the only item ever taken into consideration in estimating fire loss has been the single one of standing merchantable timber. Other items, frequently of far greater importance, but more difficult to estimate, have been overlooked entirely. Since no attempt has ever been made to secure accurate information as to the loss of standing timber, the estimates have almost without exception been far under the actual facts. A good illustration of this is the loss resulting from the severe fires in the forests of the northern peninsula of Michigan in 1906. It was stated by the commissioner of one of the railroads that of 250,000 acres in a single district along his line there was not a square mile within which fire did not appear. Severe fires occurred at the same time in six or more counties, yet the state fire warden placed the total loss at only $100,000, notwithstanding the fact that the losses were largely in perishable hard woods—maples, birch, etc.—which decay so rapidly that a satisfactory exploitation of these fire-killed woods is almost impossible. A local estimate placed the loss at $250,000. If, however, it be considered that an average acre in that region bears a stand of 5,000 feet b. m., with a stumpage value of $5 per 1,000, it will be seen that in order to cover even the latter estimate only 10,000 acres, or less than half a township, need have been burned over. The actual stumpage loss to the State from forest fires during 1906 is estimated by Prof. Filibert Roth, state forest warden, as being not less than $5,000,000, and probably far in excess of even that figure. The difficulty of securing accurate data as to fire losses will be readily admitted, since without a careful examination neither the area burned over nor the amount of timber destroyed can be determined. The information is, however, of great public value. It can not be expected that it will ever be satisfactorily furnished by private individuals or corporations. It is exceedingly desirable, therefore, that action be taken by the state and federal governments to this end. It is suggested that an attempt be made by the National Conservation Commission to secure the adoption of measures which will result in the uniform collection throughout the United States of statistics of this kind.

The time is rapidly approaching when the adoption of adequate measures for the preservation and perpetuation of our forest resources will become economically imperative. At the present time, however, stumpage prices are for the most part low, and the general adoption of any complicated system of forest management can hardly be expected. The soil and climatic conditions in the United States are, however, generally favorable to forest growth, and if protection from fires can be secured nature alone will accomplish a very great deal.

(A) DAMAGE FROM FOREST FIRE.

The damage done by forest fires may be classified under the following heads:

1. Loss of life.
2. Destruction of merchantable standing timber.
3. Destruction of young growth.
4. Effect on the distribution and composition of the forest.
5. Deterioration of the soil.
6. Injury to stream flow.
7. Injury to general business interests.

(1) LOSS OF LIFE.

More than two thousand people perished in forest fires in the United States in the nineteenth century. There have been a few great historic fires which have attracted general attention and are well known for the wide territory they have covered and the thoroughness of the destruction.

The most memorable forest fires which have occured are those in Wisconsin in 1871, in Michigan in 1881, and in Minnesota in 1894.

Forest fires raged in the northeastern part of Wisconsin in the latter part of September and first part of October, 1871, particularly in the counties on both sides of Green Bay. Four hundred square miles of territory were entirely devastated. Of several villages wiped out of existence, the principal one was Peshtigo. Governor Fairchild in a proclamation stated that the loss of life in the devastated district was at least 1,000, and 3,000 people were left entirely destitute.

The theater of the great forest fire in Michigan September 5 and the following days, 1881, was in the broad peninsula between Lake Huron and Saginaw Bay in the southeastern part of the State. The fire ran over 48 townships, a belt of timber country 60 miles in length, north and south, by from 10 to 30 miles in width, and comprising 1,000,000 acres. The number of people who perished was 138.

The village of Phillips, Wis., was burned by a forest fire July 26, 1894. Thirteen lives were lost and very much timber and other property destroyed.

In September, 1894, occurred the terrible Hinckley fire (Minnesota), in which 9 towns were destroyed and more than 600 people perished. Over 2,000 people were left destitute, and $25,000,000 worth of property was destroyed.

In September, 1902, forest fires in Oregon and Washington cost 18 lives and resulted in the destruction of timber and other property valued at more than $12,000,000.

Conditions during the year 1908 have been worse with regard to forest fires than for many years past. In British Columbia in August occurred the Fernie fire, already mentioned, where 18 people lost their lives. On October 16, near Alpena, Mich., 17 people perished while trying to escape from the little town of Metz, Presque Isle County. The town had been surrounded by forest fires which were closing in from all sides. A relief train was sent in order that the citizens of the town might escape. Two miles south of Metz the engineer saw blazing piles of cedar ties on each side of the track which had caught fire from the adjacent forest. Opening wide the throttle, he tried to dash through at full speed. About half way through the blazing ties the rails had been loosened by the heat, and the 5 cars and locomotive ran on the road bed until they came to a stop. In a moment the locomotive and cars caught fire, with the result that 17 known deaths occurred and many were severely injured by burns. Many towns through the Middle West have been threatened with destruction during the past season and a not inconsiderable number have been wiped out entirely. The complete destruction of the town of Chisholm, Minn., in September is a good example of this. No complete statement of the total number of deaths is possible. In Michigan alone, during the fire season of 1908, not less than 35 people lost their lives as a direct result of forest fires.

(2) DESTRUCTION OF STANDING TIMBER.

Large fires, such as those above described, have been comparatively few in number and of infrequent occurrence. From the earliest times, however, small fires have every year destroyed standing timber to the value of many millions of dollars, and it is these which are principally responsible for the vast aggregate of our loss from this source. The story of these fires is written in every feature of the forest, in the character of the soil and its cover, in the composition of the forest, and in the individual trees themselves.

The destruction of standing timber may occur in any one of the three following ways:

(*a*) By the killing of the timber, usually through ground or surface fires. Until within comparatively recent times but little attempt has been made toward the utilization of fire-killed timber, especially in the Western States. The worst fires have occurred in the more inaccessible regions, mainly owing to the fact that in such regions men were not available to stop the fires before they had burned themselves out. Under these conditions the utilization of dead material is clearly impracticable. Areas once burned over and on which the timber has been killed are generally more subject to later damage by fire than areas on which the timber is living. As a result of fire many trees fall to the ground after a time and furnish fuel for later fires. In many cases the same area is burned over repeatedly, the later fires destroying all the remaining seed trees which at first escaped. The result is in general a dreary, blackened waste which can be made to produce revenue only by the expenditure of large sums in forest planting.

(*b*) Injury to the individual tree. Light surface fires are frequently regarded as harmless. This, however, is far from being true, for in addition to destroying the young growth, surface fires injure many trees to such an extent that complete recovery is impossible. Through the burning of the bark at the base of the tree the inner layer of growing tissue is exposed to the air and in many cases becomes infected with fungous diseases through the spores which are generally plentiful throughout forest regions. As a result rot or dote occurs, and the value of the tree is partially or wholly lost by the time it reaches maturity. Younger trees are greatly reduced in value through the destruction of the fiber by the fungus, rendering it necessary to cut high stumps or to "butt off" a portion of the first log. The damage is especially great in the case of thin-barked species, as lodgepole pine and the spruces and firs. Western yellow pine and other species having a thick bark are comparatively unaffected by surface fires.

One of the best examples of the injurious effects of repeated grass fires on individual trees is seen in the longleaf pine forest of the South, where turpentining operations are carried on. In a virgin unboxed pine forest the damage to the tree is very slight. Perfectly sound trees seem to suffer not at all. Those on which the bark has been broken by natural causes or by chipping, to see if the grain is straight enough for rails, are slightly injured by fire igniting and charring these exposed places. As soon, however, as the trees are boxed the danger increases. During the period of operations the trees are protected by the raked circle at the base. As soon as the orchard is abandoned the raked space becomes covered with litter, and fire is easily communicated to the box and excoriated surface. The exposed face is covered with resin and the box is usually well filled with gum, both substances being highly inflammable. When flame is communicated to a box the resulting fire is of no mean importance. Not only does the resinous surface burn, but the heat is so intense that the flames, fed by the melting resin, shoot up the side of a tree, often for 25 feet. The spectacular part does not last over ten to fifteen minutes, but the box and base of the tree often continue burning for hours. To see a box burn one would not believe that the tree could survive, especially as two boxes often burn out on one tree, but it seldom happens that a tree is killed outright. The bark is wonderfully resistant and does not ignite or conduct heat even under the fiercest flame. The bark stripped off along the edge of a recently burned box is cool on the inner side, except on the very edge next to the fire.

The damage comes not from one fire, but from repeated fires. Each year the burned box and face on a tree is charred a little deeper, until at last it is burned entirely through at the base or so weakened as to allow the tree to be easily toppled over by the wind. Even if the trees live and stand there is no opportunity for them to heal over the wound, while, in addition, the removal of the antiseptic covering of wax gives access to insects and spores of fungi.

Lumbering usually follows the "turning loose" of a turpentine orchard, so that the two combined make conditions even worse. The slash furnishes fuel for hotter fires, while the opening up of the forest results in more "blow downs."

The injury to individual trees depends upon the severity of the fire, and this in turn upon the amount of grass, humus, or débris upon the ground. Many cases occur in which the vitality of the tree is injuriously affected without killing it outright. In such cases the tree is rendered much more subject to attacks by insects, such as bark beetles, than would be the case had it retained its vigor. In vigorous trees the presence of insects generally does comparatively little damage, unless they are present in great numbers. Under ordinary circumstances the number of insects is kept down by the copious flow of pitch, by which many of them are drowned. When the vitality of the tree, however, is weakened through the occurrence of fire at its base, the flow of pitch is lessened, the power of the tree to resist its enemies is partially destroyed, and it becomes much more subject to insect infestation than would otherwise be the case. Western yellow pine (*Pinus ponderosa*) is particularly subject to injury by bark beetles, though injury of this kind is not limited to any genus or species. When the beetles become so numerous that their galleries practically or completely girdle the tree under the outer bark, the death of the tree follows. Trees affected in this way become centers of infestation, from which new swarms of beetles spread and bring about the similar destruction of other trees. Very large areas of timber in the Rocky Mountains and in the Black Hills have been destroyed in this way. Insect-infested timber is usually sold at a large reduction, in order to encourage immediate utilization, and thus prevent further infestation. Unless cut within two or three years the quality of the timber becomes seriously impaired by rot, but if cut immediately the quality is not affected. Many areas of infested timber can not, however, be lumbered, unless at a distinct loss, on account of inaccessibility. There is no question but that forest fires, by rendering trees more subject to insect infestation, have resulted in the absolute loss of vast quantities of timber and in the partial loss of additional large amounts. No estimate of this loss has ever been made or can be made with any degree of accuracy.

(*c*) The third way in which timber is destroyed is through the complete burning of the timber itself. The loss here is, of course, absolute.

The actual amount of stumpage destroyed by fire can, of course, never be known. That it is appallingly large is conceded by all, and it is no exaggeration to state that more timber has been destroyed by fire than by the ax since the settlement of this country. According to an estimate based on the census figures, over 700,000,000,000 feet b. m. have been cut for lumber between 1880 and 1906. Unquestionably the amount destroyed by fire has been much greater.

The census for 1880 gives the area burned over during that year by forest fires as over 10,250,000 acres, with a property loss of over $25,000,000. This estimate is a very conservative one, since all unreliable or contradictory returns were absolutely disregarded. The following is the detailed statement:

Table of forest fires occurring during the census year.

[Tenth Census of the United States, volume 9, 1880.]

States and Territories.	Areas burned.	Value of property destroyed.	States and Territories.	Areas burned.	Value of property destroyed.
	Acres.			*Acres.*	
United States	10,274,089	$25,462,250	Minnesota	250,805	$1,395,110
Alabama	569,160	121,225	Mississippi	222,800	78,505
Alaska	....	....	Missouri	783,646	294,865
Arizona	10,240	56,000	Montana	88,020	1,128,000
Arkansas	858,115	259,470	Nebraska	....	....
California	356,815	440,750	Nevada	8,710	19,000
Colorado	113,820	935,500	New Hampshire	5,954	63,610
Connecticut	....	....	New Jersey	71,074	252,240
Dakota	....	....	New Mexico	64,034	142,075
Delaware	3,305	15,675	New York	149,491	1,210,785
District of Columbia	....	....	North Carolina	546,102	357,980
Florida	105,320	69,900	Ohio	74,114	797,170
Georgia	705,351	167,620	Oregon	132,320	593,850
Idaho	21,000	202,000	Pennsylvania	685,738	3,043,723
Illinois	48,691	45,775	Rhode Island	....	....
Indiana	90,427	130,335	South Carolina	431,730	291,225
Indian Territory	1,000	....	Tennessee	985,430	5,254,980
Iowa	11,017	45,470	Texas	599,359	273,990
Kansas	7,080	14,700	Utah	42,865	1,042,800
Kentucky	556,647	237,635	Vermont	3,941	48,466
Louisiana	64,410	6,800	Virginia	272,319	326,944
Maine	35,280	123,315	Washington	37,910	713,200
Maryland	41,076	37,425	West Virginia	476,775	155,280
Massachusetts	13,899	102,262	Wisconsin	406,298	725,610
Michigan	238,271	985,985	Wyoming	83,780	3,256,000

From year to year there is, of course, great variation both as to area burned over and damage done by forest fires. Until within the last four years, however, very little really effective work was done toward checking or fighting forest fires. The best estimates indicate that the acreage burned over in the census year (1880) is a fair average for the period immediately succeeding it. As the area of commercial forest became reduced through lumbering operations and some protection was afforded timber in the West by the creation of forest reserves, the average area of mature forest burned over annually became gradually less. This reduction in area has, however, been much more than offset by the fact that since 1880 stumpage values have increased more than fivefold. It is safe to say that from 1880 to the present time the direct annual loss occasioned by the destruction of commercial timber by forest fires has been from $25,000,000 to $100,000,000, and in some cases greatly exceeding even the latter figure. The average loss from this source alone has been not less than $50,000,000.

In a few of the States of the East and Middle West the question of protection from damage by forest fires has been agitated for a long time. As a result, forest commissions have in some cases been appointed and steps taken to determine the amount of damage done, in order that the public might be fully awakened to the necessity for taking definite action to lessen or prevent further damage from this cause. The following statistics as to areas burned over and the value of property destroyed are taken from these official reports:

Area burned over and amount of damage done by forest fires in Maine.

[From state forest reports.]

Year.	Area burned.	Damage.
	Acres.	
1903	269,451	$95,243
1904	6,958	12,655
1905	20,316	63,623
1906	7,528	20,919
1907	4,633	11,050

Annual loss in Massachusetts from forest fires.

[From State Forester's Bulletin No. 5.]

Year.	Area burned.	Damage.
	Acres.	
1885	....	$82,254
1895	....	107,150
1899	6,906	58,073
1900	51,807	140,456
1901	6,125	20,559
1902	51,578	26,526
1903	11,587	35,513
1904	1,339	14,764
Average	21,557	60,662

Figures for 1905, 1906, and 1907 not obtainable.

Acreage burned over and damage done by forest fires in Minnesota.

[From annual reports of chief fire warden of Minnesota.]

Year.	Area burned over.	Damage.	Year.	Area burned over.	Damage.
	Acres.			*Acres.*	
1895	8,265	$3,125	1902	18,285	$3,820
1896	14,912	16,059	1903	15,585	28,292
1897	66,020	22,455	1904	21,920	21,670
1898	21,580	9,063	1905	102,968	58,680
1899	3,635	1,541	1906	11,561	15,115
1900	179,521	153,399	1907	10,385	16,145
1901	6,120	2,404			

Acreage burned over and damage done by forest fires in New Jersey during the years 1872–1907.

[From report of forest park reservation, 1907.]

Year.	Number of fires.	Acres burned.	Acres per fire.	Estimated damage.	Damage per fire.
1872	....	100,000	....	$1,000,000	....
1880	54	71,074	1,316	252,240	$4,671
1885	....	128,000	....	1,128,000	....
1895	49	66,120	1,349	600,000	12,245
1902	65	98,850	1,520	169,323	2,605
1903	79	85,046	1,076	305,744	3,870
1904	81	41,530	512	193,413	2,388
1907	167	11,525	69	11,647	70

Fire damages in Adirondack and Catskill regions, New York.

[Compiled from state reports.]

Year.	Area burned over.	Estimated damage.
	Acres.	
1891	20,477	$36,626
1892	5,903	7,350
1893	10,137	11,825
1894	22,962	56,716
1895	2,448	4,309
1896	29,817	35,640
1897	26,187	26,941
1898	9,118	7,030
1899	79,653	86,893
1900	14,893	16,414
1901	7,780	3,980
1902	47,936	31,790
1903	500,518	483,116
1904	2,627	1,500
1905	27,614	24,810
1906	4,203	8,335
1907	19,800	27,853

Acreage burned over and damage done by forest fires in Pennsylvania.

[From reports of Pennsylvania Department of Forestry.]

Year.	Area burned.	Damage.
	Acres.	
1900	266,027	$834,203
1901	73,005	238,374
1902	158,572	520,573
1903	64,186	241,240
1904	63,211	135,873
1905	18,642	63,915
1906	44,495	70,070
1907	19,389	73,623

Acreage burned over and damage done by forest fires in Wisconsin.

Year.	Area burned.	Damage.
	Acres.	
1904	56,777	$867.20
1905	76,125	1,529.60
1906	35,779	878.28
1907	54,278	1,995.26

It will be noted that the figures for the damage done since 1880 are almost universally less than those given in the census estimate, and in some cases the discrepancy is very great. It should, however, be borne in mind that the States have never taken such pains to secure a careful estimate as did the Census Bureau in 1880, and that the figures given in the state reports are for the most part based upon mere guesses, since in practically no case has money been available for adequate investigations as to the actual area burned over and an estimate by a timber cruiser of the damage done. In general, little or no account has been taken of fires in the more remote and unsettled regions. Neither has there been any pretense of estimating for the young or middle-aged growth, which in a few years would have had a distinct market value. The importance of this is greatly emphasized by the rapid rise in stumpage prices and by the fact that, owing to reckless methods of lumbering and the almost total lack of protection from fire, the area of virgin commercial forest remaining uninjured by fire has rapidly decreased. It must be admitted that while the estimates in the Tenth Census are unreliable, those contained in the state reports are for the most part much more so. As a matter of fact, it is practically certain that almost without exception the figures given represent but a fraction of the actual damage. The need for reliable statistics along this line can hardly be overestimated.

(3) DESTRUCTION OF THE YOUNG GROWTH.

This is by no means the least of the damage which results from forest fires. The perpetuation of the forest by wise use constitutes the distinguishing difference between forestry and old-time lumbering. The forest should be regarded not as a mine which is exhausted when the material is once removed, but as a reproducible resource, the quantity and quality of which may by protection and management be made better than the product of nature alone and unaided. The perpetuation of the forest, however, implies the protection of the reproduction, since it is only by the development of the young trees that the mature forest is produced.

A fire in destroying mature timber kills at the same time the young trees which, had they remained, would have constituted the future forest. The damage done by surface or grass fires is not, however, generally realized. The general effect of surface fires upon young growth is well illustrated by the results of the annually occurring grass fires upon the reproduction of longleaf pine in the Southern States. Seedlings of this species if not killed outright, are injured by the killing or burning of the buds, leaves, and bark, and by the heat which injures the cambium and roots. The extent to which seedlings are injured depends primarily on their size. Certain it is that all seedlings up to an age of one year are consumed by even a light grass fire; the second year perhaps an occasional one escapes, but during the first two or three years practically all are killed, if not consumed. After this age each annual fire works more or less injury until a diameter of 2 to 4 inches is reached. A mere grass fire does not seriously injure seedlings three-eighths of an inch and more in diameter. The leaves burn off to within 1 inch of their base, but if the bud is uninjured the trees continue their growth. The bracts around the bud are very inflammable and where burned death results, but the buds are well protected by the whorl of leaves below, and hence are seldom killed. When the leader is killed, a side shoot usually takes its place. The side shoots by their horizontal or oblique position suffer more than an upright stem.

Although grass fires destroy nothing of present commercial value, they do destroy property of which the prospective or expectant value is very great. The truth of this principle will be more easily recognized with regard to forest plantations than where the young growth is the product of the unaided forces of nature. Where time and money are expended in preparing land and in planting young trees, the reasonableness of a claim for reimbursement will be readily admitted in case the plantation is maliciously or carelessly destroyed. In Europe this principle is fully recognized, and actions for damages are based upon the so-called "expectancy value" of the stand. This amount is determined by discounting for present value the amount which the stand would have been worth had it lived to maturity, making due allowance for rate of interest, time of harvest, probable amount and value of product, and other factors. Forest growth is a crop of the soil, precisely like agricultural crops, the only difference being in the manner of originating, caring for, and determining the maturity or time of harvest. This being admitted for forest plantations, it must also be admitted for areas on which reproduction is natural as distinguished from artificial, but upon the care and protection of which the owner has expended time and money with the intention of harvesting the crop when mature.

The loss due to destruction by fire of young growth upon wild forest land of mixed-age classes is no less real, since had only the mature timber been removed or destroyed the remaining young growth would have produced a commercial forest of easily ascertainable value within a definite period of time.

As emphasizing the point of view taken abroad with regard to the expectancy value of young forest growth, the attitude with regard to the insurance of forest property is of interest.

In many European countries the supply of virgin timber has long been practically exhausted, and the people are dependent upon what can be grown commercially, aided by imports from less settled regions. Stumpage values are high, and the revenue-producing value of forest land is fully realized. Under these conditions, planting is in many cases resorted to rather than natural reproduction. This involves a large initial outlay and a continual expense for necessary care. Profits are certain if the crop reaches maturity, but there is always the possibility of loss from fire or other natural agency. As a result, there has been developed a well-defined system of insurance of forest properties. With stability in business conditions, rates of insurance are reasonable, and the growing of forest crops is thus put on a sound basis and is subject to no greater risks than any other legitimate business.

In the United States the insurance of forest properties from damage by fire has been taken up in only a small way. A beginning has, however, been made and at least one company is now engaged in this class of business. With an increase in the number and size of planting operations for commercial purposes, the necessity for this form of insurance will be more fully realized and it will become as common as it is now in some parts of Europe.

It has been customary in the past for Americans to consider forest land of value only for its actual stand of merchantable timber. Of late years, however, the value of absolute forest land is coming to be recognized on account of its ability to create value through the production of wood crops, just as farming land is valued because of its ability to produce agricultural crops. Ownership in the land should be regarded as an investment and the wood crop as interest. Where the reproduction is destroyed, it may be anywhere from a few years to several centuries before a natural regeneration can take place and the land be again restocked. In the meantime the land is practically idle and the investment is producing no return to the owner. This is as true where the owner is the federal or a state government as it is where the land is owned by a corporation or individual.

The loss of time involved in the natural restocking of a burned-over area varies greatly according to the size of the burn, the number, kind, and location of seed trees, and soil and climatic conditions. Very large clearings or burns can not be restocked from trees now standing on the border. It is usually a question of the progression of the forest on the clearing by successive generations of trees. The seed trees now standing distribute seed as far as the wind will carry it, and reproduction occurs in greater or less amount within that range. Near the seed trees the stand may be good; farther away the forest is more open, and on the edge there are merely outposts representing the seed borne to unusual distances by exceptional winds. As soon as these trees are large enough to bear seed, reproduction will occur in the openings about them, and there will be a further advance of the forest. This will continue until the entire area has been restocked. This process is exceedingly slow, compared with the results obtained by planting or by natural regeneration where young growth has been preserved and protected.

How much the loss by the destruction of young forest growth amounts to each year is difficult to conceive, even approximately. There are about 600,000,000 acres of woodland in the United States. It may be assumed that 200,000,000 acres of this area are in forest still uncut and not burned, leaving 400,000,000 acres of cut-over and burned-over land. This land varies greatly in productiveness, but it is safe to estimate that on the average it is capable of producing an annual growth of 20 cubic feet per acre. Protection from fire alone would have secured this result had preventive measures been taken from the beginning. Proper management would greatly increase it. Over very large areas, natural reproduction can not now be depended upon, owing to unfavorable soil conditions and the absence of seed trees. Thus a great expense for artificial reforestation will become necessary to repair the damage caused by long neglect. The producing capacity of the 400,000,000 acres with fire protection alone would thus be 8,000,000,000 cubic feet, equivalent to 40,000,000,000 feet b. m. per year. On account of the destruction of seed trees and of young growth by forest fires, it is estimated that not to exceed one-fifth of this amount is actually being produced on this area. This leaves a net loss to the country of 32,000,000,000 board feet per annum. At $2 per thousand stumpage this represents an annual loss to the country of $64,000,000. The annual loss thus directly due to the failure of the country to adopt measures for the prevention and control of forest fires is equivalent to 80 per cent of the total lumber cut of the United States, or to 32 per cent of the total consumption of wood materials of all kinds.

There is another point of view from which this loss may be estimated. It may be conservatively stated that 5,000,000 acres of land are burned over each year on which there is a stand of young growth which, if protected, would become a valuable stand of commercial timber. It costs on an average not less than $10 per acre to plant cut-over or burned-over lands. At this rate the annual loss to the country from the destruction of young growth alone is not less than $50,000,000. As a matter of fact, the actual direct loss from this source is much greater. The above figure makes no allowance for the fact that if the area is replanted, the forest will be but 3 or 4 years old, while that destroyed will usually average considerably older, varying from 1 to perhaps 50 years. The loss of interest on the investment represented by the value of the land during the time thus lost is an important consideration.

(4) EFFECT ON DISTRIBUTION AND COMPOSITION OF THE FOREST.

Forest fires affect not only the composition or make-up of the forest, but its distribution as well. Where repeated fires result in the total destruction of the forest cover, its replacement through natural means depends upon many conditions, and may not take place for hundreds or thousands of years, if at all. In general, the replacement of the forest on large areas of burned-over lands in the Rocky Mountain region is exceedingly slow, while in the coast region and in the eastern States it is much more rapid.

The change in the composition of the forest depends entirely upon the intensity of the fire. When great damage is inflicted upon the soil, its ability to produce spontaneously a crop of trees similar to the one destroyed is lost, and the subsequent forest is only produced if at all, through the restoration of fertility, following the slow growth and decay of many generations of less valuable plants. On the other hand, where the fire is light, burning merely slash resulting from old cuttings, and destroying the reproduction without doing any material injury to the soil, it is not many years before a new vegetation establishes itself and no real change is brought about in the composition of the forest.

The time required to seed a burned area with the valuable species destroyed depends entirely upon the severity and extent of the fire. The light-winged seeds of the conifers travel great distances, but a complete seeding of the ground can not be depended upon for a greater distance than one-quarter of a mile from the parent tree. Assuming that a conifer must be at least 30 years old before it can produce fertile seed, it would take at least thirty years to seed a burn over half a mile in diameter, at least sixty years to seed a burn 1 mile in diameter, etc.

The spruce forest of the Northeast consists chiefly of an uneven stand of spruce, balsam, birch, maple, yellow birch, white pine, etc. When burned over the ground becomes occupied by a temporary type of light-demanding species, such as fireweed, bird cherry, popple, soft maple, and birch. The last three species are good sprouters and grow from roots already well established. The popple often grows from underground stems or suckers, thus adding materially to the rapidity with which it comes in upon burned areas. As these light-demanding trees grow in height the confers, being quite tolerant, come in under the shade afforded by the former and establish themselves in the stand. Birch, popple, bird cherry, and soft maple grow very rapidly at first, but they are not at all persistent in their height growth, and are soon overtopped and killed by the slower-growing but more persistent conifer. With the death and disappearance of the above-named hard woods, the forest resumes its coniferous character.

In the white-pine region of New England and Pennsylvania the prominent type is a mixture of white pine, red, white, and black oak, chestnut, maple, ash, etc., the hard woods tending to occupy the better soils. When a severe fire occurs, destroying the vegetable matter in the soil and killing young growth and seed trees, freer seeding and less exacting species like gray birch and pitch pine, and such shrubs as scrub oak and laurel, take possession. Eventually, however, the area will revert to its original type, as in the case of the spruce forest.

Where the fires are less severe, killing only the young growth and not injuring the soil, the effect is usually to favor the free-sprouting hard woods, which occur naturally on the better soils. As this is a prominent type it then becomes difficult for the more valuable white pines to recover the ground which they have lost.

In the upland longleaf pine region of the South, after an area has been culled by lumbermen so that only a thin stand remains and the ground is burned so closely as to prevent pine reproduction, there often occurs a thick stand of jack, scarlet, post, and upland willow oaks. There is thus formed a two-storied forest, with these oaks as the under story. The large pines in such a forest are present in varying numbers, from 30 to 40 per acre to 3 or 4, or occasionally entirely wanting over limited areas. The tendency of such a condition is to reduce the number and severity of the fires. The oaks by their shade reduce the density of the grass cover and the number of low shrubs so that often there is not sufficient fuel to support a fire. The bunches of wire grass are widely separated, and as the fallen oak leaves do not carry fire unless there is much head, a running fire soon loses headway unless fanned by a strong wind. Land of this character presents one of the most hopeless and deplorable features of fire injury. It is not safe to say that this worthless oak would not spring up upon the cutting of longleaf pine, but it would not cover the ground so exclusively were it not for the fires which kill the longleaf pine seedlings, which would compete against it for possession of the ground. With fire as an ally the oaks have all the advantage. Another advantage is the frequent oak mast as compared to the rare production of longleaf pine seeds. Even if both seed the ground and the seedlings share alike for the first year or two, the inevitable fire will kill the pines outright, whereas the oak will be killed to the ground only to sprout anew the following year or often the same season. The sprouts grow with marvelous rapidity and soon get above the fire danger and shade out the few pines that perhaps escaped the first fire. Once in possession of the ground, the oaks give no further opportunity for pines to establish themselves. Except for the damage to the soil there can be no harm resulting from fire in oak scrub land. If the oaks are injured so much the better. Prevention of the fires which give the oaks first possession is the thing to be sought for.

The effect of the fires upon the loblolly pine land of eastern Maryland and Virginia is illustrated by great stretches of waste land covered with a thick tangle of huckleberry, laurel, green brier, etc., with a scattering of loblolly and other pines. The loblolly is a free seeder and would take possession again were it not for the recurrent fires.

In a shortleaf pine region fire results in great damage to the forest. The reproduction of pine is largely prevented and an undesirable growth of inferior hardwood sprouts results, as described for the longleaf region.

In the Rocky Mountain region the struggle of the trees is not so much against each other as against adverse climatic conditions. Of these the most important is the low annual precipitation. Fires in that region have resulted in the laying waste of vast areas. The fact that seed years of the native species may occur only at infrequent or irregular intervals intensifies the uncertainty of reforestation through natural means. This is especially true of Engelmann spruce in the Rockies. Unless favorable climatic conditions and a good seed year happen to occur at the same time the seeds fail to sprout or the seedlings fail to live and the establishment of a new stand is delayed indefinitely. Seed, moreover, is not always plentifully produced, because in this high altitude and peculiar location the meteorological conditions are anything but favorable to regular, abundant seed production, and when seed is produced a large portion of it becomes food for birds and other animals. Of a large area in the southern portion of the Pike National Forest, Colorado, burned over about 1850, less than 10 per cent is estimated to have become restocked through natural means.

Two trees, however, are well adapted to cope with fire, the aspen and the lodgepole pine. The former certainly and the latter in many cases may be regarded as temporary types preparing the way for more valuable species like Douglas fir, yellow pine, and Engelmann spruce.

The relation of lodgepole pine reproduction to fire is an especially interesting one. In the first place, the cones often do not open, but remain on the trees for many years; and in the second place it demands a mineral soil in order to germinate well. Since fire provides a mineral soil and opens the cones, the lodgepole pine is favored by it, and the tremendous areas of logpole forests in the Rockies are largely the result of fire. This is not always true, however, for if the fire should come before the stand has reached seed-bearing age complete destruction will result. The reversion of timber land to chaparral, through repeated fires which kill the reproduction and eventually the seed trees, is one of the serious problems in the commercial forests. The chaparral is able to endure these repeated fires, since it sprouts from the root. It has in this way obtained possession of enormous areas once densely forested. One of the best examples in northern California is seen around the base of Mount Shasta.

The unwritten history of the Southwest is phenomenal. The prehistoric aborigines must have exerted a marked influence upon the vegetation of the country. Their fires, and those of the historic races, unquestionably account for the open condition of the forests. The high pine forests were their hunting grounds, and the vast areas of foothills and plateaus, covered with oak and nut-bearing pines, their harvest fields. Here they lived in their summer homes, kindled their camp fires, and harvested crops of acorns, nutritious nuts, and in many instances cultivated vegetables and cereals.

Possibly no forests on the Pacific coast show so small a percentage of regrowth and so slight a tendency to reproduction as do the forests of the Mogollon Mountains, which extend through New Mexico and Arizona. This is due not entirely to the arid condition, as is popularly supposed, but to the continued occupancy of the country for centuries by prehistoric races, who merged into the Indian tribes occupying the country at the present time. All through Arizona the regrowth of pine forests dates somewhere during the past half century, and with a few exceptions nowhere antedates the early settlement of the country by our own race.

From Puget Sound to the Gulf of California these people rambled at will, but their abiding place was on the border land between the forests proper and the "Staked Plains" in the Southwest. The extensive ruins indicate that they inhabited the fringe, so to speak, of the forests which, like vineyards, were working their way down from the mountain tops into the desert plains. The most potent and powerful weapon in the hands of these aborigines was a firebrand. It was alike used to capture the deer, the elk, and the antelope, and also to rout or vanquish the enemy. It cleared their mountain trail and destroyed the cover in which their quarry took refuge.

In the North nature was quick to heal the ravages of fire, and the damage of forest growth was reduced to the minimum. In the dry and more arid regions nature recuperated slowly, and the relentless flames left an indelible mark. In Chaco Canyon, where a deep arroyo or wash has cut the depth of 30 feet through a sedimentary formation, distinct strata of earth, impregnated with charcoal, from 15 to 20 feet from the surface, may be traced over an area of many thousands of acres. Elsewhere the alluvial and silt deposits and forest trees have recorded the unmistakable evidence of numerous and extensive forest fires which have occurred at intervals during many centuries.

How far the occupancy of the prehistoric and historic tribes has retarded the progress of foresting it is impossible to say, but it must have been no small factor. These areas—that is, those most frequented by the cliff, caveta, and pueblo builders—were then and are now of great importance, because in the region inhabited by them the battle between vegetation and the unfriendly elements was and is now fiercest. These areas form the boundary between the forest and the desert. Vegetation is here dwarfed, but struggling to enlarge its domain. Were it not for the long Indian occupancy and the ravages of fire incident to their habitancy, vast territories now barren wastes might be covered with a forest growth, at least such as is indigenous to arid regions. Irrigation would have reclaimed many hundreds of acres now hopelessly barren.

In Arizona there are no young forests of any considerable extent antedating a period of forty years and almost all of the regrowth has sprung up during the last quarter of a century. A single exception may be noted in the White Mountains, which have been occupied for a couple of centuries by the Apache Indian. These forests show in certain localities all classes of regrowth and are in marked contrast to the mountain country occupied by the Navajo Indians in the northeastern portion of the Territory. The Navajos have possessed sheep and goats and followed pastoral pursuits for over two centuries. The forests occupied by them show practically no regrowth. The Apaches have followed the chase and war and have entrammeled themselves with nothing but war ponies. The forests within their domain, where they have not seen fit to apply the torch in accord with their well-grounded supersitition that forest fires cause rain, show a regrowth gradating into many past decades.

Fire, with or without the aid of lumbering, is directly responsible for the chaparral upon the western slopes and foothill regions of the mountains of California. Of three and a half million acres examined in the mountains of Butte, Plumas, Sierra, Nevada, Yuba, and Placer counties, in southern and central California, approximately 213,730 acres are under chaparral cover. If an artificial grouping were made it would throw the chaparral into two types of classes: (1) That which has evidently been in possession for a long period of time, and (2) That which has taken possession since lumbering and fire removed or thinned the forest growth. In one case natural causes, mainly fire, are responsible; in the other largely the result of man through lumbering. In both cases the chaparral covers the sites of former forests, the main difference being the time and rapidity of the transition.

The first-mentioned type is found mainly at the higher elevation, seldom below 4,000 feet. These high, brush-covered ridges show external evidence of having been timbered, examination revealing the presence of old stubs and charred logs among the densest chaparral, often entirely covered with soil; while the soil conditions are as good as in the adjoining timber. Each succeeding fire reduces these evidences of former timber growth, kills a few more trees along the disputed boundary, and extends the line of chaparral farther back into the forest. The principal reason for the rapid advance of the chaparral at the expense of the forest on the higher elevations is that fewer species and less fire-resisting ones occupy these upper slopes. The fir, especially until the polewood stage is passed, is very susceptible to fire. It is, however, one of the first species to work back into the chaparral, and in many places would regain possession if it were not for recurring fires.

The chaparral of the lower slopes is practically the same as the other, save that it has appeared more recently, and is the direct result of lumbering followed by successive fires which killed the reproduction and the thinned stand of culled timber. The result of the change in composition of the forest from commercial timber to chaparral is that the capacity of the land to produce revenue in the shape of a valuable crop is lost for an indefinite period. An additional point is that the chaparral is less valuable as a protection to the watershed than a forest cover since the latter produces better conditions of soil and humus and is more effective in preventing evaporation. The presence of the chaparral cover, however, renders planting operations so difficult and so expensive that reforestation with commercial species is in most cases impracticable as a business measure.

In hardwood forests, in general, the effect of fire is to reduce the percentage of seedling trees, and to increase the number of sprouts. As sprouts rarely produce first-class timber, the result is deterioration of the forest. Fire also favors the freer-sprouting, faster-growing species like the chestnut and the black oaks, and the less exacting species. Frequent killing back, however, reduces the vitality of the stools and often kills them entirely so that large areas become covered with such shrubs as laurel, rhododendron, huckleberry, etc.

The effect of fire in the sprout forests, because of the density of the stand and moderate height of the trees together with the crookedness and irregular forms of growth, is even more destructive than in seedling forests of similar species. In young stands the destruction is often complete while the dead, half-burned stems that remain standing add to the danger of a second fire.

Many of the so-called prairies are capable of bearing forests and possibly were originally timbered. This is not only true of the great prairie belts of the Middle States where the western line of forests has been pushed far to the east through the agency of fire, but is also true of the prairies found within forest regions, such as those occurring in southern Minnesota, Illinois, Tennessee, etc. In many of the interior prairies forest conditions are already becoming rapidly established since the prevalence of fires has been decreased.

(5) DETERIORATION OF THE SOIL.

It is impossible to estimate even approximately the loss caused by the deterioration of the soil due to forest fires. In mountainous regions there is no question that the loss from this source is frequently greater than from the destruction of the original stand of timber. The building up of the soil in mountain regions is a matter of evolution, resulting from the decomposition of rock in place and of the vegetable matter formed by many generations of lower plants, or by the washing down of these constituents from higher slopes. On many slopes the presence of any forest growth whatever is due to the accumulation through the ages of a mass of organic matter which held the mineral particles of rock as they were gradually disintegrated, preventing their being washed to the bottom of the slope. It may take hundreds or thousands of years for the soil on a slope to reach a sufficient depth to produce a stand of commercial timber. When the forest growth and other ground cover are destroyed by fire and the organic matter partially or totally burned, the bare, shallow, mineral soil is left to be blown away by violent winds and to be washed away by the rains. The capacity of the area thus denuded to produce a valuable crop is in this way delayed indefinitely, and at the same time immense damage may be done by the deposit of soil thus washed down upon valuable farm lands below. This has been notoriously the case in the Southern Appalachian Mountains.

Where the slopes are not sufficiently steep to facilitate the washing away of the soil, forest fires by destroying the humus may affect injuriously both the fertility and the physical condition of the soil. The loss in fertility is of the lesser importance since of the constituents necessary to tree growth, one-half, namely, carbon, is furnished by the air, and almost all of the other half is furnished by the water of the soil. In general the soil is increased in fertility by the presence of forest growth, while the opposite is true of agricultural crops. The damage to soil fertility on lands not suitable for agriculture may thus be overrated, so far as the mineral composition is concerned.

The fertility of the soil for the support of forest growth is, however, much more to be found in the physical condition than in its mineral composition. In the case of agricultural lands the physical conditions can be regulated by artificial means, as by plowing and cultivating. This, however, is impracticable to any extent with regard to forest lands. The surface cover has an important influence on the physical conditions of the soil, and its destruction by fire may be most detrimental. Changes in soil conditions primarily affect water supply and stream flow, and for that reason will be discussed under the next heading. For the purposes of this subdivision it need only be remembered that the amount of wood increment is in proportion to soil conditions, and that a deterioration of these is reflected in a reduced annual wood deposit as long as the unfavorable conditions last. There is thus a distinct loss due to the rate of growth having been damaged, and the amount of wood increment being correspondingly decreased as a result of forest fires.

(6) INJURY TO STREAM FLOW.

Investigations indicate that the presence or absence of forest cover has but little if any influence in increasing the rainfall and the annual run-off. There is no question, however, but that the forest does subserve an exceedingly important function in regulating the disposition of the precipitation after it reaches the ground. It shades the soil and breaks the force of the wind, thus lessening evaporation, both of soil moisture and of rainfall. The result is that a larger percentage of the precipitation passes into the streams, either directly as a part of the surface drainage, or indirectly through seepage, and thus becomes available for irrigation or other purposes. The effect of forest cover in retarding surface drainage is also well recognized. This is accomplished by the mechanical effect of the vegetation in retarding the flow of surface water and by its function as an absorbent, changing the rapid surface run-off, with its great possibilities for damage, to the slower process of seepage drainage, whereby the volume of stream flow is equalized and its occurrence distributed through longer periods of time.

Where the forest fires result in the partial or total destruction of the forest cover the nice balance of nature is destroyed and the above conditions are reversed. The result is that snows melt more rapidly in the spring of the year, the soil washes away, or its physical condition is so changed that its capacity to absorb and retain precipitation is damaged, and an alternation of floods and droughts occurs, in place of the former comparatively steady stream flow. The value of streams for irrigation, power, and navigation is greatly lessened on this account, since the volume may be greatly decreased, or the flow cease entirely during the dry season, when it is most needed. Greatly increased facilities for the storage of water become necessary in case the water is to be used for irrigation. This added expense is further increased by the additional damage done by the silting up of reservoirs at times of flood water.

Concrete examples are not wanting, which demonstrate the results bound to follow if present lumbering methods are not modified and protection from fire secured.

A point not often considered is the effect of forest fires in increasing the number and severity of snowslides and landslides. It is a well-known fact that in Europe not only torrents, but landslides and snowslides are induced and aggravated by the removal of the forest cover, and also that the formation of these slides has been prevented by reforesting the denuded mountain slopes. Timber at high altitudes affords the best protection against snowslides. The importance of the forest in this respect was recognized in the Alps centuries ago, and wherever "ban" forests were maintained, immunity from avalanches to the extent of the forest has been secured. An interesting account is given of the ban forest of Urseren, which was reserved by the community as early as 1397, and of the constant fight which was necessary against reckless advisers to keep it intact, until now the beneficial effect is fully recognized and reforestations have been begun under the protecting walls or other safety works wherever the danger of avalanches exists.

Yet even timber forest is not absolute protection against avalanches, since the place of incipient formation of the slide may lie above timber line. There is no question, however, that the interlacing of the roots of trees has a decided tendency to prevent movements of the soil, and the mechanical obstruction furnished by the trees themselves is an important factor in preventing the inception of snow and land slides and in checking them when once formed. Conversely, the destruction of the forest cover at high elevations through the agency of fire, while not necessarily an original cause, undoubtedly contributes to the evil effect.

Snowslides are frequent in the Rocky Mountain region, more especially among the higher Colorado ranges. Hardly a year passes without the report of serious loss of life and property from this source from the regions near Silverton, Ouray, Aspen, and Leadville. In a number of instances entire mining camps have been engulfed. Landslides are of less frequent occurrence, but they do nevertheless occur, and are of increasingly frequent occurrence with the settlement of the country and the consequent denudation of forest lands on the steeper slopes.

In addition to the loss of life and property, the occurrence of snowslides has a bearing upon streamflow. The mechanical effect of both snow and land slides in removing the soil covering from steep, rocky slopes and in preparing the way for further washing and gullying is well known. But little attention has, however, been paid to the effect of snowslides upon the distribution of streamflow throughout the year. The snow which falls at high elevations naturally melts less rapidly than that which is deposited upon the lower slopes. A snowslide results in the transfer of an immense volume of snow from a higher to a lower altitude. Under the new conditions the snow in general melts more rapidly than would have been the case had it remained on the higher slopes. In addition, it must escape chiefly as surface run-off, instead of soaking gradually into the soil at the higher elevations and seeping out below all through the year as a feeder to the springs and smaller streams. The result is that instead of a moderate flow extending all through the year there is a flood in the early spring, resulting in excessive erosion of agricultural lands above, the silting up of dams and reservoirs, and the destruction of or great injury to valley lands below by the deposition of vast quantities of soil and gravel washed down from the hills. Then, following the flood, occurs a period of excessively low water or absolute drought, making impossible the utilization of the natural capacity of the soil for storage purposes, and rendering it necessary, in order to utilize the stream for irrigation, to incur great expense in the construction of storage dams and reservoirs, the maintenance of which is in turn made more costly on account of the tendency of the stream to carry an excessive amount of silt during its high stages.

(7) INJURY TO GENERAL BUSINESS INTERESTS.

The vital relationship existing between the lumbering industry and the great industries of transportation, agriculture, mining, and manufacture is unquestionable. The forest furnishes raw material which is indispensable in all, and in addition furnishes a not inconsiderate portion of the traffic upon which the prosperity of the railroads depends. Forest fires, by destroying vast quantities of standing timber and making the natural restoration of the forest impossible over large areas, have seriously lessened the available present and future supply of timber and thus brought about a general increase in the cost of raw material. This has in many cases resulted in decreasing profits, though as a general rule the increased cost of raw material has brought about a corresponding increase in the price of the finished product, the loss thus being transmitted to the general public. Forest fires, however, brought about the direct destruction of a vast amount of private property in the form of buildings and manufacturing plants of all kinds. By destroying in many cases the only available source of raw material, they have made necessary the closing down of business enterprises, thus rendering the money invested in manufacturing plants a partial or total loss. This is particularly true of lumbering operations and sawmills. It is true also to a certain extent of pulp mills, since an expensive plant is of less value where it can be supplied for only a limited period of time than if the supply were sufficient to permit operation for an indefinite period. Fires, by destroying young growth, cut off the future supply and make necessary the earlier removal of plants than would be the case were the forest protected and made to yield a continuous crop.

Nor is even this all. Over large areas the forest is killed and the material made worthless, but the accumulation of millions of cords of this material still remain on the ground, which soon decays and loses its sale value. It takes many years, however, before decay becomes complete. It is material of this kind which furnishes fuel for the terrible fires which occasionally sweep over vast areas. In Michigan the forest fires of 1871 killed great quantities of timber; the fires of 1881 devoured the stuff thus killed a decade before, and were rendered unusually severe because of the vast quantities of débris. For years the areas run over in 1896 will be in danger of renewed and more severe fires. The constant menace of fire is a thing to be avoided, since it imperils not only all the property in its way, but human life itself. The clearing of these burned-over wastes is a severe task, and the settler is not able to partially reimburse himself for his work by the sale of logs, as would be the case were the timber uninjured. As a result of these conditions, settlement in burned-over areas progresses very slowly, even where the land is fairly well suited for agriculture, as it is in most parts of the Middle West. It is stated by the forest warden of Michigan that forest fires have done more to hinder settlement in the northern counties of that State than all other agencies combined.

An additional point not generally considered in connection with the destruction of timber is the fact that the community as a whole is injuriously affected, since its power for development through taxation is decreased. Under our present system of taxation, unimproved, burned-over land must necessarily be assessed at a much lower rate, for purposes of taxation, than when it contained a stand of merchantable timber. This is especially true where the land is not chiefly valuable for agriculture but serves its best purpose as a producer of wood crops. Where settlements exist, an increased burden of taxation is cast upon other forms of property for the maintenance of roads and schools and other incidents to local government. In other words, in order to raise a fixed sum of money the tax rate must be raised in order to compensate for the decrease in the amount of taxable property. This in turn is reflected in a general lowering in the values of all forms of property thus taxed. Where settlements do not exist, development is greatly retarded, since the lack of taxable property renders the construction and maintenance of roads and schools a difficult matter. In fact, in many parts of the country, the combined effects of lumbering and fires has been to bring about the reversion to the State of vast areas of land for nonpayment of taxes. A notable instance in this regard is the State of Michigan. There were in that State, in 1907, 9,000,000 acres of state-tax lands, of which not less than 7,000,000 acres were, according to Professor Roth, cut-over lands, mostly pinery, burned and reburned, with the exception of the swamps. The reversion of these lands to the State withdrew them from taxation entirely, and as a result the development of the counties in which they were located has been exceedingly limited and slow. Had it not been for fires it would, in many cases, have been good business policy for the owners of the land to retain it in order to allow the young and middle-aged growth to attain maturity and be harvested. These lands would in the meantime have been subject to taxation and would thus have aided in the settlement and development of such portions of the region as were chiefly valuable for agriculture. The reforesting of such lands by the State and the payment to the county of a portion of the revenue, in lieu of taxes, offers the best solution of the problem, under present conditions.

Many of the mountain regions of the United States derive a large revenue from summer visitors. For instance, the White Mountains, in New England, and the Adirondacks, in New York, are visited annually by thousands of people from every State in the Union as well as from foreign countries. These regions form vast recreation grounds for thousands of people. Their very existence as summer resorts depends to a large extent upon the beauty of the landscape and the clearness of the atmosphere. The natural beauty of the mountains is enhanced by their forest covering, and when this is destroyed by fire the landscape is rendered bleak and unattractive, thereby lessening the volume of travel. The result is directly translatable into a decreased revenue for the region so affected. What is true in this regard in the White Mountains and Adirondacks is true to an equal or greater extent in many other summer-resort regions throughout the United States.

The relation of forest fires to the naval-stores industry of the South has until recently received little or no attention. Turpentining has been followed by lumbering, so that the disappearance of the virgin forest has progressed steadily. This process has been accelerated by the weakening of the trees due to the burning out of the boxes by grass fires, so that the trees are easily blown down and immediate lumbering becomes necessary. Restocking and natural replacement of the forest have been made impossible over immense areas by the annually recurring grass fires, which destroy the seedlings before they can reach sufficient size to withstand the flames. The condition above described is to a very considerable extent responsible for the fact that the naval-stores industry in the South has never yet been placed upon a permanent basis. The depletion of the forest has occurred in one State after another, beginning with North Carolina and working steadily southward and westward.

The industry has unquestionably been conducted, for the most part, with the intention of obtaining the greatest return for the immediate outlay, irrespective of the waste and wanton destruction of the forests. The fear of exhausting the raw material of the live trees has led to the adoption in some localities of the Herty cup and gutter system. While this system undoubtedly brings about the protection of standing timber and an increase in the quality and quantity of the product, it does not bring about the perpetuation of the forest as such. There is no reason why the lumber and naval-stores industries should not be perpetuated together. Protection from fire in the southern forests would alone bring about the accomplishment of both these objects to a very considerable extent.

More importance is being attached to the second-growth pine than formerly. It is only in recent years that the owners of timber in the Southern States have had an opportunity of noting the value of this second growth and of forming some idea of the possibilities of this character of timber for the development of naval stores. The second growth, following the abandonment of old fields and the cutting away of permanent growth, has developed to the extent of service for turpentining purposes. It is the consensus of opinion among the operators to-day that if fires can be prevented the turpentine industry will be perpetuated, while a few years ago the prevailing opinion was that the turpentine industry would soon be a thing of the past in Florida. It is only recently that naval-stores operators considered it practicable to depend solely upon a second growth for turpentining. Now, however, it is reported that many of them believe that in the years to come there will be turpentine made from second growth alone and that the industry will be as successful then as now. If forest fires can be kept out, there is no question but that this is entirely practicable.

B. CAUSES OF FOREST FIRES.

The fire reports of forest supervisors, while applying only to the national forests, may be taken as a fair indication of the relative importance of the various causes of forest fires throughout the Western States, including the Rocky Mountain and coast regions and the Southwest. Of a total of 2,503 fires occurring in the national forests during the calendar years 1906 and 1907, 641 were reported as having been caused by railroad locomotives, 638 by campers, 458 by lightning, 49 by clearing and brush burning, 43 incendiary, 22 by hunters, and 652 from miscellaneous causes. These figures, while not complete, are sufficient to demonstrate the fact that the principal causes of forest fires in the Western States are railroad locomotives, campers, and lightning. Loss from the first two can be largely overcome by proper precautionary measures. The starting of forest fires by lightning can not be prevented, but it is entirely practicable to greatly reduce the loss by the adoption of some definite plan for extinguishing fires in their early stages.

To be classed with fires caused by railroad locomotives are those caused by donkey engines and sawmills. The loss from these sources, while comparatively small, is great in the aggregate. Since lumbering by donkey engines takes place only on the Pacific slope, the region subject to fires from this cause is limited in extent. Fires from sawmills occur at irregular intervals throughout the entire country wherever the mills are located in the midst of the lumbering operations. That the amount of loss from both these causes as well as from railroad locomotives can be very greatly decreased by precautionary measures has been amply proven by experience. The two most effective means to this end are the use of spark arresters and of oil burners. This has been demonstrated by the experience of the Forest Service in the protection and administration of the national forests.

During the year 1907, 273 fires were started upon the National Forests as a result of sparks from locomotives. There were during that year 32 Forests affected by railroad companies which burn coal and wood as fuel in their locomotives, many of which do not provide their locomotives with spark arresters. The reports upon these fires show that 75 per cent of the fires were started from locomotives not provided with spark arresters. During this same year 65 fires resulted from donkey engines used upon lumbering areas. It is required, however, that these engines be provided with spark arresters, since in all permits allowing the use of steam power a clause is inserted in the final agreement to this effect. It has been difficult to secure the general adoption of spark arresters, since all or nearly all the styles now in use interfere to some extent with the completeness of the draft. Especially on mountain roads does the ordinary type of spark arrester interfere with the steaming power. In many cases engineers have either removed the arresters or screens or else broken them, in order to increase the steaming power, so that the efficiency of the device as a preventive of fires along the right of way was entirely destroyed. The remedy lies in the selection of the best types of spark arresters and in the enforcement of the laws already existing requiring their use. It is, of course, essential that some system of inspection be provided by which it will be guaranteed that the screens will be kept in proper condition. Many types of spark arresters are in use, based upon different theories, and using different sizes of mesh in the screen. The standard spark arrester used by the Pennsylvania Railroad Company has a mesh of two and a half openings to the linear inch, using wire to No. 10 gauge (0.11 inch in diameter), reducing the size of the opening to 0.0841 of 1 square inch. It is believed by the officials of this company that instead of a device for catching the sparks and retaining them long enough to become cold, it is better to break them up into small sizes and throw them as high as possible. This gives them time to cool below ignition point before landing. Observation shows that in general sparks from an engine equipped with a spark arrester will fall inside of 20 feet from the track, while one not so equipped will throw sparks a distance of 50 feet, and on a very heavy up grade to as great a distance as 75 feet.

The importance of keeping the right of way cleared of inflammable material is apparent.

Donkey engines are generally fired with refuse wood and limbs resulting from lumbering operations. This fuel contains more or less pitch, and this, acted upon by smoke and steam, forms a coating over the ordinary old-style screen, very seriously interfering with the draft. When this occurs the engineer usually either removes the screen or, in endeavoring to clean it with a rod or pole, so injures it that it is entirely useless for the purpose for which it was designed. Several improved styles have been designed to meet these difficulties, and the results are most encouraging.

The advantage of using oil as fuel in locomotives in preference to coal or wood, in decreasing the danger from fires, has been clearly shown by the results obtained upon the national forests. There are 912 miles of railroad within the national forests representing 38 different railroad companies. Of these, 25 companies use coal and wood in their locomotives and 6 use oil as fuel. From the 6 railroads burning oil, representing a distance of 82 miles, not a single fire was reported, while 273 fires were started by locomotives using coal or wood. That portion of the Southern Pacific Railroad traversing northern California may be cited as an example. On this portion of the line the coal-burning engines were converted into oil burning, and oil is now used exclusively as fuel. As a result the fire danger is reduced to a minimum, timber fires having been entirely eliminated, and there being no recurrence of the former difficulty with regard to fires in the snowsheds across the summit of the Sierra Nevada.

It is the policy of the Forest Service in connection with timber sales where railroad transportation is required, wherever such stipulation is considered reasonable, to insert in the final contract a regulation requiring the use of oil as fuel for the locomotives during the dry season of the year.

The substitution of electricity for coal as a motive power on railroads also offers great promise for the future safety of the adjacent forest from fire. It is announced that on that portion of the Chicago, Milwaukee and St. Paul Railroad which will traverse mountainous or timbered regions from the Rocky Mountains to the coast, electricity will be the motive power rather than coal. It is reported also that the same action will be taken by the new Western Pacific Railroad in crossing the Sierras in California, and that the Great Northern Railroad is planning to substitute electricity for steam in crossing the Rockies and the Cascades. Local water power will generate the electricity in each case.

Experiments carried on by the New York Central Railroad Company have demonstrated the entire practicability of this course. The extreme cost of transporting coal long distances in mountain regions, as contrasted with the convenient accessibility of water power as a source of electricity in these same regions, will gradually bring about a more general adoption of the example set by the Chicago, Milwaukee and St. Paul Company.

The second great cause of forest fires throughout the West has been the carelessness of campers and of others traveling through the forest. Thoughtlessness, ignorance, and disregard of any but personal welfare have been largely responsible for this condition. Camp fires left unextinguished and lighted cigars thrown away have caused many fires. Many set intentionally have been allowed to spread over large areas. Formerly it was a common practice in many parts of the West for sheepmen to burn over the ranges to open up the way for their herds and to get fresh grass and tender sprouts in the spring. These fires have frequently spread into standing timber and caused incalculable loss. In some cases prospectors have set the brush on fire to make traveling easier and to expose the rocks, thus facilitating the work on which they were engaged. The setting of fires to improve the range or to facilitate prospecting has been practically eliminated so far as the national forests are concerned. Carelessness and ignorance are not so easily reached, but much has been accomplished through education, patrol, and the enforcement of penalties in accordance with law. It is a fact that the worst fires have followed the advent of the whites, notwithstanding the fact that the Indians systematically fired many portions of the country to keep the woods open, and the early Spanish herdsmen in California burned the brush to facilitate travel and open up the country. Fires are also caused by lightning, toward the extinguishment of which in the early days absolutely no steps were taken.

The causes of forest fires named above for the western States are responsible in varying degrees for fires throughout the East South, and Middle West.

In the East and Middle West, while immense damage has been done by fires starting from locomotives, the principal source of danger has for a long time been the clearing of land for cultivation. The periods of greatest danger are in the months of April and May before the leaves have unfolded on the trees, and in September and October after the leaves have fallen. Numerous fires are also caused by the carelessness of hunters, campers, and fishermen. A strict enforcement of existing laws has already materially reduced the loss from these sources, as it has from the clearing of land for agricultural purposes. In many of the States a closed season has been established during which the burning of brush or fallows is made unlawful, or is allowed only under permit issued by firewardens, whose appointment is provided for by law. As a result there has been a very noticeable decrease in the number and severity of fallow fires. In some of the States the improvement has been so great that the damage from this source is very materially less than from fires set by locomotives.

The burning over of so-called blueberry or huckleberry barrens has been another fruitful source of fire damage in many of the Northern and Eastern States. In New England, New York, New Jersey, Michigan, and the mountain districts of Pennsylvania and West Virginia, there are many thousands of acres, worthless for agricultural purposes, upon which, after the removal of the timber and the burning over of the slash, there has sprung up an abundant growth of blueberry bushes, alders, poplars, birches, spiræa, and sweet fern. These lands have in general been considered as public property and recklessly burned over by irresponsible parties to promote the growth of blueberries and to destroy the birches and other plants which would soon shade the ground. The result has been that the fires have year after year encroached more and more on the forested areas, in this way destroying large quantities of valuable timber. Where the burning is done too late in the spring the roots of the bushes are severely injured and a period of ten to fifteen years is required before they regain their producing capacity. In some parts of the country, however, particularly in Maine, the management of blueberry lands has been systematized, and the picking and canning of blueberries has become an industrial operation. Good blueberry land, properly managed, yields a handsome revenue. Economically considered, therefore, the blueberry barrens are in many cases justified. Unregulated burning, however, results in the loss of large quantities of valuable timber, the deterioration of the barrens themselves, and the retention in many cases as comparatively unproductive barrens of lands that would otherwise be producing a valuable crop of commercial timber.

Throughout the Southern States it has been the practice for generations to burn over the woods every year or two. Practically the whole forest burns over annually, usually between December 15 and April 15. Except in the swamps a piece of forest land that has remained unburned five years or more is rare. Practically all the fires are set intentionally.

The principal objects sought to be gained by these fires are: (*a*) To protect turpentine orchards by burning all combustible material at the time of the year when it will cause least injury to the naval-stores industry. Fires are ordinarily regarded as inevitable, and light annual burnings are considered as causing less damage to the mature timber than heavy fires at less frequent intervals; (*b*) to improve the range; (*c*) to protect fences and crops by burning the combustible material on surrounding areas; (*d*) to keep down reproduction and undergrowth and render the woods easy of access at all times.

The fire question is of paramount importance in the Southern States on account of its vital relation to the three forest industries of lumbering, turpentining, and stock grazing. It has been shown by experience that cattle exist quite as well on an unburned range. In fact, many of the more intelligent stockmen have for some time opposed all burning. That these annually recurring fires are resulting not only in the destruction of the present forest but in the prevention of a future one over vast areas is shown elsewhere in this paper. The present deplorable condition of the southern pineries is directly traceable to this source. The only excuse for periodic burning is that it reduces the severity and damage of fires, which it is said are bound to start accidentally if not set intentionally. This, however, is not necessarily true, provided careful and systematic measures are taken to prevent and promptly control all fires.

C. PREVENTION AND CONTROL.

All experience goes to prove that damage by forest fires is practically preventable. This stage of development has already been reached in Europe. For example, of 7,000,000 acres in Prussia, an average of only 1,400 acres, or one-fiftieth of 1 per cent, was burned over each year during the period from 1868 to 1895. This forest contained extensive areas of dry, sandy, pine land, where the fire danger was very great. In the mountainous forests of Bavaria, between 1877 and 1881, only 1 acre in 13,167, or seven one-thousandths of 1 per cent, was burned over. That the same results will in time be obtained in the United States there is no reason to doubt. Many beginnings along this line have in fact already been made, and the results so far obtained, even though frequently on a small scale, offer every encouragement for satisfactory results from future efforts. It must, of course, be remembered that conditions in Europe and in the United States are very different. The large population of the peasant class makes it possible to utilize even the smaller branches and the leaves, thus for the most part removing the medium by which fires are transmitted from one part of the forest to another.

The discussion which has preceded regarding the various forms of damage resulting from forest fires shows conclusively that the nation as a whole can not afford to sustain the immense annual loss which has resulted from this source since before the beginning of the first settlements. The great difficulty has been that while this fact has to a certain extent been recognized by a few individuals and by the Federal Government, it has never yet thoroughly penetrated the consciousness of the people as a whole. Federal legislation has been delayed until vast areas have been devastated almost beyond repair; only a comparatively small number of the States have taken action, and even then the action has for the most part been totally inadequate to meet the situation; in only a pitifully small number of cases has definite action been taken by private owners, whether corporations or individuals. A beginning has, however, been made, and with the inevitable decrease in our timber supplies and the consequent rise in prices will come a constantly increasing realization of the absolute necessity of conserving what remnants are still left of our once magnificent forests. In proportion as this realization grows will definite steps be taken for the perpetuation of the forest upon lands not more valuable for other purposes. Experience in this country, as well as abroad, demonstrates beyond a doubt that the best business policy is one of prevention. The old adage that "an ounce of prevention is better than a pound of cure" holds here absolutely, for two reasons: (1) The cash outlay for preventing forest fires is actually less than for fighting them after they have once secured a start; unquestionably some fires are sure to occur, but when proper precautions have been taken they can be extinguished in their earlier stages at a small cost as compared with the outlay necessary after the fire has gained headway; (2) under the policy of prevention the various kinds of damage already enumerated are for the most part avoided. The saving thus secured is almost without exception many times greater than the cost of protection. To wait until the fire occurs before taking action is to lock the stable door after the horse is stolen.

Fire measures may be classed under three heads: Administrative, legislative, and educative. The aim of the second and third is to secure a more general adoption of the first.

(1) ADMINISTRATIVE MEASURES.

PREVENTION.

Of administrative measures for the prevention of forest fires, the most effective are: Patrol, brush burning, and judicious grazing. For the control of fires the best measures are: Fire lines, back firing, the construction of roads, trails, and telephone lines, and the use of lookout points and observation towers.

PATROL.

Of preventive measures by far the most important is patrol, since without it the others can prove of but little avail. The necessity of maintaining a regular patrol during the fire season can not in fact be overestimated. To leave the extinguishment of fires until they have grown to such proportions that they attract public attention is to defeat the object sought, since by that time the damage sought to be avoided will already have taken place, at least in part. The superior efficiency of a well-organized, paid fire patrol over volunteers or local officers appointed as fire wardens has been thoroughly demonstrated wherever it has been tried. The size of patrol districts depends first upon the funds available for the purpose, then upon the topography of the country, the amount and character of the timber, the amount of combustible material on the ground, the character of the season, the amount and sources of fire danger, and the efficiency of the patrolman. On the national forests the area of ranger districts varies from 40,000 to 200,000 acres, the former figure applying to the southern California forests, where there is extreme danger from fire and where the importance of the forest and ground cover as a watershed protection is greater than anywhere else in the United States.

In connection with the prevention of forest fires by patrol the following statement by Col. W. F. Fox, of the New York State Forest, Fish, and Game Commission, is of interest as showing the difficulty presented by one phase of the problem in the United States:

> The problem presented by the railroads is the most serious of all. We hope now to compel them to patrol their roads thoroughly during the dangerous seasons. Still, railroad patrols will not entirely eliminate the fires caused by locomotives. Even if we were to put them on one man to a mile, a fire could start between two of them in a dry time and attain dangerous headway before it could be noticed. There are only two remedies for railroad fires:
>
> 1. The forest floor along the line of the railroad must be kept as clean as in Germany.
>
> 2. The companies must use petroleum or electricity on their locomotives.
>
> The time has come when the State of New York has got to choose between its railroads and its forests. I am satisfied that we can not have both unless some stringent measures are enacted.
>
> As you are aware, the German forests are traversed by railroads to as great a degree as our own. Their immunity from fire is due to the fact that there is nothing on the ground aside from leaves that will burn; but the forests along our railroads are so filled with inflammable material on the ground that in a dry time a spark is very apt to flash them. During the drought of last year we were about as helpless in the matter of railroads as the superintendent of a powder mill would be if he allowed visitors to travel through his works, each one with a lighted cigar.

BRUSH BURNING.

In general, the hottest and most difficult fires to control are those which occur in the slash resulting from old lumbering operations. The removal of this menace is essential to the success of any operation looking toward the perpetuation of the forest. Of the various methods of reaching this end, one of the most effective is the burning of brush or slash either at the time of the lumbering operation or at its conclusion. Unfortunately, experiments to determine the practicability and cost of this method have, with very few exceptions, been carried on only upon the National Forests. The following statement is taken from the Forest Service circular entitled "Suggestions for the Disposal of Brush in the National Forests," by J. S. Holmes:

> The piling and burning of brush on the National Forests has been required for the purpose of fire protection, but experience has shown that it is not always advisable. Every case should be considered separately and the question of brush disposal settled according to the special needs of the area in question.
>
> ADVANTAGES OF BRUSH BURNING.
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> The greatest advantage of brush burning is the protection it gives against fire. In many cases brush burning is the only practicable safeguard against fire. After the average lumbering operation the ground is covered with slash, scattered about or piled, just as the swampers have left it. This, in the dry season, is a veritable fire trap. Probably 90 per cent of all uncontrolled cuttings are burnt over, which retards the second crop at least from fifty to one hundred years and perhaps permanently changes the composition of the forest. Fires may be set by loggers while still at work on the area or several years after by lightning, campers, or locomotives. By piling the brush and burning it in wet weather or in snow, when there is no danger of the fire spreading, all inflammable material is removed, and the second growth can come up without serious risk of being destroyed. Even where only part of the brush is burned and the rest is piled, as when the piles in open places, along ridges, streams, or laid off lines are burned, very much is gained in case of fire, since these cleared lanes form bases from which a fire may be fought.
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> Besides lessening the danger from fire, brush burning has certain minor advantages. When the brush on the ground is removed it is much easier for rangers and others to ride or walk through the forest. This may be very important in case of a fire or in rounding up cattle. It is also much easier to cut and handle ties, cordwood, or other timber which may later be taken from the cut-over area if the slash is out of the way. By piling and burning the green brush as it is cut from the trees by the swampers, as is now being done in Minnesota and parts of Montana, the ground is cleared and skidding is made easier and cheaper. Again, careful piling and burning of brush improves the appearance of the forest. There is nothing much more unsightly than a recently cut-over area where no attempt has been made to dispose of tops and lops. Near towns or resorts and along roads or streams frequented by tourists this point should be carefully considered, but as a general rule the utility of the forest should not be sacrificed for beauty.
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> DISADVANTAGES OF BURNING.
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> The disadvantages of burning brush are many and, with the one exception of protection from fire, far outweigh the advantages. If protection can be had in some other way, as with more efficient patrol service or more stringent laws, the practice should in many cases be abandoned. In many places, especially in the yellow-pine type, the best, and often the only, reproduction comes up under a fallen tree top or other brush. Where there is little of the old stand left, the straggling open top protects the seedlings from the direct heat of the sun. Yet brush not only protects the seedlings from the sun, but, what is more important, the leaves and broken twigs form a cover which retards evaporation of moisture from the soil. Over the greater part of the West the soil dries out very rapidly during the dry season, and this seriously retards or even prevents the growth of seedlings. Even in the moister regions, such as that of the Engelmann spruce type, it is very necessary to conserve the moisture in the soil after logging to prevent the remaining trees from being killed through lack of soil moisture. A third reason why seedlings so often come up only under the down tree tops is that they are protected from stock. Next to drought, sheep are perhaps the most serious menace to reproduction, and though it would be best to keep all stock off the area for several years after logging, in many cases this is not practicable, and on many areas the leaving of the tops on the ground is the only way to protect reproduction from injury.
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> In many places after the timber has been cut off gullies and washes start in the old wheel ruts, log slides, etc., and these and other forms of erosion can best be prevented by leaving the brush on the ground, either laid in the incipient washes or scattered over the soil that is likely to wash. Brush burning de-

stroys the valuable soil cover, and on the spots where the piles are burned the soil is loosened, which renders it even more liable to erosion.

It is well known that where the forest is burned each year the soil becomes poorer and poorer, because nitrogen, the chief fertilizing ingredient of the soil, is given off in the smoke, and only the mineral elements go back to the soil in the ashes. And, what is more injurious, the humus, i. e., the decomposed vegetable matter in the top soil, is destroyed. In burning brush after logging all the fertilizing and humus-forming leaves and twigs are destroyed just when most needed, for another good crop of leaves can not be expected for many years.

The burning of brush not only removes from the soil its natural manure, but renders it unfit for the germination and growth of seedlings. This is especially true of Engelmann spruce. Douglas and white fir also in the Southwest will not come up after fire. The area of ground covered by piles for burning varies according to the type and to the density of the forest, but an average of from 5 to 10 per cent of the total area is thus made nonproductive. If full reproduction could be procured on the rest of the area, this would make very little difference, but where reproduction is scattered and hard to procure, as in the Southwest, it would probably make considerable difference in the final stand.

The added cost, both to the lumberman and to the Government, is another argument against brush burning. The cost of piling brush has varied all the way from 15 cents to $1 or more per thousand, with an average of 40 or 50 cents, while the cost of burning may be from 5 cents to 25 cents per thousand, averaging about 15 cents. By abandoning the practice of brush piling, this 60 cents a thousand will not be entirely saved, as is claimed by some, for the brush will still have to be lopped and disposed of in some other way, which will cost, it is estimated, at least half as much as piling and burning. But even a saving of 25 or 30 cents a thousand is a strong argument against the practice.

Thus, from a silvicultural viewpoint, the disadvantages of brush burning far outweigh its advantages. Yet, as a general policy, it seems unwise, until other methods have proved their efficiency, to abandon brush piling and burning to any great extent at present. The fire danger is a known quantity, and though it is being reduced each year it is still a menace. Therefore changes from the present practice should be made with caution. Brush piling and burning is certainly not advisable in all cases, and extensive experiments should be made to determine what is the best method of brush disposal for the different types and conditions.

Brush Piling and Burning.

The cost of piling varies with the cost of labor, the methods of logging, the type, the topography, the kind of trees cut, and the time of year it is done. A few figures will illustrate this variation. In the yellow-pine type in Montana an addition to the swampers' wages of 15 cents a thousand would, it is said, enable them to pile the brush, as they have to handle it anyway. Usually, however, the piling is done by a separate crew. Much of the work is thus duplicated. In yellow pine in the Southwest, brush piling costs from 45 to 50 cents, while in Montana it can be done for 25 cents. One operator in lodgepole in Montana says it is cheaper for him to pile than not to, because he can get his skidding done so much cheaper, yet on other operations it has cost from 50 cents to $1 a thousand, depending on how thoroughly it is cleaned up. In the sugar-pine yellow-pine type of California, the cost of piling averages from 25 to 35 cents, while the cost in the Douglas fir type, in Montana and Idaho, averages about 40 cents, and in Engelmann spruce type the cost is only about 25 cents a thousand. It is certain, however, that the cost of piling will everywhere be materially reduced when the operators begin to look on piling as part of the swampers' regular work and not as an entirely separate job.

Dry brush should never be burned during the dry season, unless absolutely necessary for the suppression of an insect invasion. Green brush in some places may be burned at any time, but as a rule it is unsafe to burn it in dry weather. The best time to burn brush is in the fall, just after the first snowfall. Then the piles are dry, and there is no danger that the fire will get beyond control. Brush may also be burned at the beginning of or during the rainy season, when the ground is damp enough to prevent the fire from spreading, and the brush dry enough to burn readily.

The cost of brush burning varies like the cost of piling. It varies even more in the same localities, with weather conditions and methods of piling. Brush that can be burned for 10 or 15 cents a thousand at a favorable time, as just after the first snow, will cost 5 or 10 times as much to burn in dry weather, or when the piles are very wet. Brush can be burned more easily the first fall after cutting than it can the second year, when many of the leaves have fallen off. Brush burning has been done for 13 cents a thousand in lodgepole, in the Medicine Bow National Forest, while it has cost 22 cents in similar timber in the Yellowstone, and estimates of 40 cents a thousand have been made for it in the Rockies. It is generally admitted that brush can be most economically burned by the same people who pile it. Recently several contracts have been made in which the purchaser of the timber is required to pile and burn the brush under the direction of forest officers, as has been the practice in the Minnesota forest for some time. This will lighten the total cost, and when the weather allows the brush to be burned, as logging proceeds, the cost of burning will be offset by the subsequent reduction in the cost of skidding.

Piling Without Burning.

Brush piled properly, even though it is not burned, is a great protection to the forest. Inflammable material is removed from among the living trees, and should a fire occur it would be much easier to fight. This is especially true where reproduction is dense. Where openings are scarce piles should be made in the most open places, and may be larger than those made to be burned.

Ground Burning.

Where clear cutting is practiced and fire assists the reproduction that is wanted, ground burning is sometimes advisable. The slash is left scattered as in primitive lumbering operations, and after an efficient fire line has been made around the area it is burned off clean. The fire line should be thoroughly cleaned up before the area is fired. Great care will have to be exercised to prevent the starting of a crown fire, which can not be controlled even with wide fire lines. The brush should usually be fired against the wind, and should the wind change after the fire is started the brush on the opposite side of the tract should be back fired. This method is the only practical way to secure reproduction of desirable species in some parts of the country.

Lopping and Scattering.

Where it is best to lop the tops and scatter them over the ground, the lopping should be done thoroughly, so that the top logs and larger branches will lie flat on the ground. If the object is to prevent erosion, the brush should be scattered or roughly piled where washing is most likely to occur. If washing has already started in wheel ruts, log slides, etc., brush should be laid in these as compactly as possible. If good-sized gullies have formed, it is usually better to put the brush in them in compact piles, filling them from side to side, than to scatter some brush all along them. If the chief object in scattering the brush is the conservation of moisture, it should be scattered evenly over the ground within reasonable distance of where it is felled, care being taken to keep the brush at safe distance from living trees. Where brush is scattered, fire lines should be made at intervals by piling and burning the brush in lanes 200 or 300 feet wide. This diminishes very greatly the danger from fire, by isolating different areas in the forest and giving places where back firing can be started. The cost of lopping and scattering brush in this way has not been determined, but it is thought that it can be done for from 50 to 75 per cent of the cost of piling and burning.

Grazing.

The fact should not be overlooked that judicious grazing in coniferous forests is a benefit rather than an injury. Not only does it not prevent reproduction where the range is not overstocked, but it aids very materially in making it possible to protect the forest from damage by fire. Where the range is not utilized, or incompletely so, a thick covering of dead grass accumulates on the ground, which burns readily, carrying the fire over large areas, destroying young growth, injuring middle-aged and mature timber, and setting fire to any inflammable material that may be within reach. Where there is a sufficient amount of dead timber on the ground to hold fire, the living trees are usually killed and partial or total loss of the property results. On the national forests throughout the Western States protection from fire has been most difficult on grazing lands which could not be utilized on account of lack of springs or streams for stock-watering purposes. A good example of the damage resulting indirectly from this condition is the Paulina Mountains fire, which burned from August 2 to 23, 1908, in the Deschutes National Forest, Oregon. There is no surface water in or near the vicinity; it has, therefore, not been possible to utilize the range, and as a result the ground was covered with a heavy covering of dead grass under the growing vegetation. The cause of the fire is attributed to lightning.

The region where the fire occurred is remote from settlement and before help could be secured to fight the fire it had assumed great proportions, covering a front of 40 miles. It was 50 miles to a base of supplies and 16 miles to water. Men had to be brought distances varying from 50 to 150 miles, and over 100 were employed in fighting the fire. Though 240,000,000 feet of green yellow pine was killed and 3,000,000 feet of dead pine destroyed, an immense amount of timber was saved that would have been destroyed but for the efforts of the forest officers. The point, however, is that had the region been moderately grazed the large amount of dry grass would not have been present on the ground, the fire could not have traveled as it did, and the damage would have been but a small fraction of that which actually occurred. An additional point is that where stock is grazed the presence of men to care for them is required; and these men are invaluable in aiding forest rangers and local residents, if there be any, in discovering and extinguishing fires before they gain headway. The development of water on dry ranges, in the form of wells or springs, and its retention in troughs or reservoirs, for the use of stock, would go a long way toward making possible the prevention and control of forest fires in remote and inaccessible regions. This is a strong argument in favor of the policy which the Forest Service has adopted of developing the range as fast as the necessary funds can be made available.

REMOVAL OF DÉBRIS.

In many cases it is entirely practicable to prevent damage to standing timber in case of fire by removing the combustible material from the base of the trees.

Mr. T. B. Walker, one of the largest owners of timber lands in northern California, gives the following description of the method adopted upon some of his tracts:

> In the spring of 1902 I sent a crew of men into a large tract of timber on the headwaters of Fall River, in northern California, who were known as the "fire brigade." They were fully equipped with teams, camping outfit, tools, etc. After establishing their camp in a particular locality the section was divided into 40-acre tracts, and each two of eight of the men went upon four separate divisions and systematically began the work of clearing away around the foot of each tree all the needles, leaves, cones, brush, limbs, pieces of stubs or logs that lay against or near the roots of the tree. Each was supplied with tools, one carrying a shovel and ax, the other a shovel and crosscut saw. With the shovel they scraped away all the loose materials to the distance of several feet from the tree, and with the ax and saw they chopped or sawed any larger pieces, which were then rolled away. All trees having burned spots or hollow places, after clearing out and away from them all the leaves and loose materials,

loose dirt was thrown against the spots and the hollow places filled, so that when another fire came they would be protected. The bark of these trees is very thick and furnishes a very natural protection against the running fire. It is only where an extra amount of fuel is accumulated against the side of one of them that it can be burned through sufficiently to injure the tree. But when a burned spot is once formed the pitch runs out and forms a coating or bunch that is very combustible when fire again comes, if it reaches to it. But by means of clearing away the material and covering up the pitch and hollow spot the bark will re-form and cover the damaged place, so that future fires will do no damage until another accumulation of fuel, as in the original burning.

There is hardly any such thing as a sweeping fire in California in the uncut forest that consumes or destroys any considerable number of trees. It is only through a gradual process of damage at the root of the tree in the manner above specified, where, after a burned spot is once formed, the next fire enlarges it through the large cavity formed, which in the course of years enlarges so as to leave only a shell of the trunk of the tree, and finally to so burn it away that it falls and throws a large top with its leaves and cones alongside of other trees.

This great amount of fuel renders the trees against which it has fallen liable to the same kind of process of gradual and sometimes immediate destruction when the next fire occurs. The fire brigade is expected to clear away all such fallen tops to whatever extent they endanger other trees. A tree may be injured many times by having spots burned where all of them may gradually be healed over without much permanent injury to the tree, and where a spot is formed is enlarged from time to time by repeated fires, it may take a great many years, a quarter or half a century, perhaps, or more, to destroy the tree.

Now, at any time from the foundation of the burned spot to the time that the tree is burned down, this process will protect it from further damage, and if there is enough wood to keep the tree from blowing over, the process of repair and growth will be resumed as soon as the ravages by fire are stopped.

METHODS OF FIRE CONTROL.

Fire lines are one of the most effective means of controlling serious fires. Their value, however, depends largely on the character of the ground cover, and in some regions their use is not advisable. Moreover, their width, location, and manner of construction vary with local conditions, all of which must be decided by local study on individual tracts. In the southern pineries, and wherever the aim is to stop grass fires, the main fire lines should be plowed strips from 10 to 30 feet wide, with a narrower parallel line some 40 to 100 feet distant. The space between the two lines can often be burned over to great advantage. In timber land with a brushy undergrowth fire lines are usually impracticable, but if made should be 40 to 100 feet wide to be at all effective—the wider the better. Fire lines on cut-over lands are often of high value, and should be of varying width in accordance with the condition of the inflammable ground cover. Cleared or burned strips 100 or more feet wide are often essential. In pure brush growth, such as is commonly known as chaparral in California, fire lines are very essential, if fires are to be quickly controlled. They should be widest in "saddles" and where the brush is densest, and of minimum width on the crests of sharp ridges. A width of from 15 to 50 feet or more is usually advisable. The brush should be cut off close to the ground and the roots grubbed out if possible. All such lines should be connected with trails.

Much depends on the location of fire lines. They should not be expected ordinarily to stop a fire, but rather serve as an indispensible vantage point from which to back fire or to beat out flames which jump over. Fire lines should take advantage of topographical features and be located where fires are naturally reduced in their progress or severity. This is usually on the crests of ridges or where the brush or forest is open or the ground bare. An important consideration in all fire-line construction is to plan for the removal of all dead stubs for a distance of at least 200 feet on each side. In case of fire these stubs ignite readily, and the wind carries sparks and firebrands from the tops for long distances.

Closely associated with fire lines is the question of back firing, and plans, based on local conditions, should be made for this use of fire in fighting fire. Back firing should be resorted to only when absolutely necessary, and never save under competent supervision.

If fire should get a good start in old slashings or logging works, it might be useless to make a fight until it reaches a skid road or stream, or possibly green timber. If it can not be checked until it reaches green timber, it is best to go back far enough into the timber so that the heat and smoke will not drive out the fire fighters. If there is no road or skid road in the timber where a stand can be made, and if the ground is fairly level, a trail should be cut around the head of the fire from 10 to 20 feet wide, and brush, rotten wood, moss, etc., cleaned out and piled on the side next to the fire. A back fire should then be started. In back firing it is most essential to see that the fire does not creep or blow back across the trail. It is dangerous to back fire unless enough help is available to control it. When fire strikes the green timber it will probably burn some tree tops, but when the tops and brush along the edge of the timber have been burned, it will die down and creep in the moss and brush on the ground and it can then probably be stopped at the trail. If, after the fire has died down, there are any dead snags left standing with fire near the top, they should be cut down.

Fire rushes uphill, crosses the crest of the hill slowly and is more or less checked in traveling down. If the fire is running uphill, especially with the wind behind it, it may be impossible to handle it until it reaches the top. If such is the case the best place to cut the trail is just beyond the crest of the hill, where there will be less smoke and where the fire will naturally be checked in running downhill.

The fire should be watched until it is entirely out. The first fire burns above the surface of the ground, and there is apt to be fire left smouldering underneath for days. The trail should be watched as long as smoke can be seen, and as soon as it cools down what fire there is left should be dug out. Dry sand or earth is usually as effective as water (and much easier to get) when thrown on a fire. Fires burn faster in the heat of the day and are more easily controlled at night or in the early morning.

In all plans of fire protection provision must be made for an emergency fire-fighting force. The labor arrangements at the mill or in the camp must be studied, and a force of competent men selected who can drop everything at a moment's notice and proceed to a fire. This force should be made up of men who can be spared temporarily without shutting down any part of the mill or interfering with logging operations. One or more experienced men should be designated to act as leaders of the fire-fighting squads.

Plans should be made for storing suitable fire-fighting tools at readily accessible points. One set should be at the mill or camp where the emergency force is working, and others in settlers' cabins or special tool houses on different parts of the tract. The location of these sets of tools should be determined by a field study. The tools usually needed are axes, spades, rakes, and buckets, and canteens for the personal use of the men.

Where fires frequently start along logging railroads it has occasionally been found advisable to equip a flat car with a water tank and force pump for use in extinguishing fires near the track. This, however, is rarely necessary, but should be considered. A more effective means of preventing the spread of fire from locomotives is to clear or burn a strip 200 or more feet wide on each side of the track. These lines should be made part of the general fire-line system.

Trails are indispensable on ordinary forest tracts, in order that all parts may be readily accessible. In connection with fire protection they are needed by patrolmen, and in order that fires may be reached without delay. Wherever possible trails should be laid out with the contingency in mind that they may at some later date be developed into roads.

On large holdings the location of lookout points should be decided upon if their use is advisable. They should be located, if possible, on the regular trails. The value of lookout stations will be determined largely by the topography and size of the tract. They are naturally of the greatest value in mountainous regions and practically useless in a level country. Sightly points should be selected for these stations, and provision made when advisable for cabins and for permanent observers during the season of fire danger.

In connection with the trails and lookout stations the construction of telephone lines is of great value, since by this means it is possible to secure help quickly in case of fire without the necessity of the patrolman leaving his district for that purpose. The existing means of communication, the need of call boxes along the trails, and the necessity of giving the men at lookout stations direct communication with headquarters should be the determining factors in locating telephone lines.

FIRE FIGHTING BY REGIONS.

It is impracticable here to include detailed and definite instructions to cover local fire-fighting problems; on the other hand, conditions so vary that no set of rules can be given that will apply universally. Eastern and western forests differ, and there are regional differences within these two great areas. Altogether there are eight distinct areas as regards forest fires, each of the eight having peculiar features that distinguish it from the others. Those in the East include the spruce forests of the Northeast; the woodlot that is characteristic of the New England and Middle Atlantic States, and the Ohio Valley region; the hardwood forests of the Southeast, including particularly the Southern Appalachian region; and the coastal pine belt of the Southeast and South. Then there is the Lake States region, and in the West the Rocky Mountains, the Pacific Northwest, and California, particularly the southern part.

Fighting fires in the Northeastern States.—The principal forest regions of the Northeast are characterized by dense stands of conifers, and by open hardwood stands with heavy undergrowth. The ground is covered, for the most part, with a thick layer of humus or "duff," which may carry a fire for a long time and not show it. Forest fires in this region are most common in early spring—April and May—

but are likely to occur also, though with less frequency, in the early fall—September and October. In the spring the ground is covered with a thick layer of dead leaves. With the advent of the warm sun and the south wind these become so dry that they ignite easily and burn quickly, with a blaze fierce enough to communicate itself to the dry refuse of old cuttings and to dead trees.

Two classes of fires are recognized in this region, ground and crown fires. Where there is only a light surface fire, the most common and least expensive way is to put it out with green branches, wet sacks, or wet blankets. This method is effective if the fire is attacked early enough, and if great care is used to see that the fire is actually all out and not driven from the surface down into the duff.

Where the fire is more severe and there is plenty of water, a common method is to institute a "bucket brigade," whose members pass buckets of water from a stream to the fire line. The water is rarely used against a main fire, because there it would be largely wasted, but rather to quench numerous small blazes that are started by sparks from the big one.

Where water is unavailable, sand or earth is thrown on the small blazes. This is harder work, but is more effective, unless the earth used is composed of humus or vegetable mold. In that case it apparently smothers the fire, but eventually adds fuel to it.

The best way, however, to stop a ground fire, and often the only sure way, is by trenching. This is simply digging down to the mineral soil and throwing the dirt toward the fire. This is a costly and a hard task; to be successful it must be done so far ahead of the fire that the mineral soil can be reached before the fire gets a chance to cross over. A faster method, but not so sure, is to dig holes in a line a rod or so apart and spread the dirt along the ground between the holes. Sometimes furrows may be plowed or fire lines may be cleared ahead of an advancing fire.

Crown fires can not be attacked directly unless the fire is small and the conditions unusually favorable. The flames travel so rapidly and jump such long distances that nothing can be done, except a long way in front of them. Lines may be cleared along the edges of the fire to prevent its spread laterally. Back firing is an extreme to be made use of when all other methods fail, and then only under the direction of an experienced person. The danger, particularly when there is a wind, is that the back fire may spread and add its fury to that of the original fire. When it can not be started from and held to a fixed line and forced back toward the main fire, a modification may be adopted to burn over an extended area far ahead of the on-coming blaze, which will go out from lack of fuel when it reaches the burned-over portion. In order to minimize the danger of having the precautionary fire get beyond control, the area to be burned may be divided into small sections, and each fired separately. This plan is analogous to the dynamiting of blocks of buildings to stop a city conflagration, and should not be resorted to except in extreme cases where valuable property is at stake.

Railroads in the Adirondacks use special devices for fire fighting. The Rumford Falls and Rangeley Lakes Railroad in western Maine has hose of extra strength, which, attached to a locomotive's pump, sustains a pressure of 90 pounds, sufficient to throw a half-inch stream about 100 yards. The jet of water trained on a tree is strong enough to tear off the bark, and will shatter burning stumps. It has been used with very satisfactory results.

The fires in the Rangeley Lake region of 1903 were generally fought by crews of about a dozen men, whose leaders had a code of signals by which the work could be correlated and reenforcements sent to points of particular danger. Usually the crews were called out at 3 o'clock in the morning and continued fighting until 1 o'clock in the afternoon, when the wind was so strong that no work could be done, except by scouts ahead who kept little fires from starting in advance of the big ones. Then in the evening when the wind went down with the sun, and the fire largely changed back to a ground fire, work would be resumed for a few hours until the night winds came up.

Protection of the woodlot.—It has been estimated that one-third of the total stand of timber in the United States is in farmers' holdings. The woodlot is thus an important part of the forest resources of the country.

The successful protection of the woodlot from fire requires three conditions: Proper organization, efficient watching, and facilities for fighting fire. By organization of a woodlot for fire protection is meant the establishment of such a condition that fires may most easily be prevented from starting, and that fires which do start may most readily be extinguished. The measures usually practical in this woodlot organization are, first, the disposal of tops and dead brush, and, second, a construction of fire lines. A fire in leaves may be put out entirely, but if tops, old logs, and snags lie scattered about, the fire may smolder in them for a long period and remain a constant menace after the main fire is out. It is especially desirable to prevent the accumulation of inflammable trash near roads and paths where smokers and hunters are liable to set fires.

The best fire lines for the woodlot are roads and paths. Their first purpose is to make the different parts of the woods readily accessible. In a city the effectiveness of a fire department depends on the degree of quickness it can reach a fire. In the same way, the forest traversed by roads and paths by which an incipient fire can be reached quickly is in the best condition for protection. Roads and paths will check an ordinary fire. Many fires are absolutely stopped by a dirt road, and small fires will not cross a dirt trail. If back firing is absolutely necessary, it is best done from a road or path. An opening in the forest may be a vantage point from which to fight fires, but as a check to fire it is only slightly better than no opening unless cleared entirely of inflammable material. Ordinarily, if the roads are adapted to use as fire lines, and if there are roads or trails near those boundaries where danger exists, the woodlot is well organized.

Constant watchfulness during the danger season is absolutely necessary. A woodlot that is not watched is not protected. Usually a woodlot is in close proximity to the cultivated portion of the farm, and it involves very little additional trouble to watch for fire. During very dry periods it is sometimes desirable to actually patrol a lot two or three times a day.

It is necessary not only that the fire be discovered quickly and reached quickly, but there must also be ready facilities for attacking it. The watcher must have the necessary tools readily accessible,

i. e., axes, shovels, rakes, and water pails. He should also be able to secure help quickly in case he can not handle the fire alone. The best system is to have a cooperative understanding among a group of neighbors to assist each other in case of fire.

The South.—Broadly speaking, the fires within the mountain region of the South are surface fires which consume only down timber, young growth, slashings, leaves, and other forest litter. These fires are set by careless hunters, by sparks from locomotives and sawmills, or intentionally by cattle owners to improve (as generally erroneously believed) the spring grazing.

Whatever the cause of the fire, each owner of forest land should use every effort at his command to extinguish the fire at the earliest possible moment. If taken in time at the early stages, one man can often beat it out with brush or surround it by raking away the leaves. If delayed a short time, the assistance of neighbors will be required, but usually the efforts of such organized fire fighters are directed not so much to extinguishing the fire as to turning it aside from the farm buildings, fences, or dry crops of the owners directly interested at the time.

In a mountain region large and small owners in a section of country, say of a county or a watershed of a stream, should combine for protective measures in preventing and fighting forest fires within the section. Such an organization should employ a fire warden and one fire guard for about each 10,000 acres of land. The duties of the fire guard would be to patrol or keep a lookout from vantage points during the dangerous season of early spring and fall and seasons of drought. Behind the fire warden and guards every owner of timber land within reach of a reported fire, with his employees in logging camps, sawmills, farms, or tenants, should be prepared to go to the fire immediately and stay with it until extinguished.

Fire usually travels slowly in the hard-wood region of the mountains, and a line of men with rakes, shovels, and brush should easily control any ordinary conflagration. With a brisk wind and a rapid fire the line of men should retreat to the next stream, dry run, or crest of a ridge and make a fire line about 5 feet wide by raking away the inflammable litter. Back fires should then be set along the side of the line toward the fire, with the men keeping watch to see that it does not cross the line.

The cost of this system of protection should be distributed among the owners of timber land within the protected areas in proportion to the acreage of their respective holdings. Where patrol is only necessary for short periods two or three times a year the expense should not be more than a fraction of a cent per acre, and is more than justified by the amount of timber it may save from fire left to run until it burns itself out or is extinguished by a chance rain storm.

Throughout the rolling hills of the Piedmont Plateau, contiguous bodies of large timbered areas are infrequent, and the timber is generally confined to large wood lots and pasturages of plantations. Here it is more clearly the problem of the individual owner to take care of the fires arising on his own land, but, again, the cooperation of timber-land owners in each community or settlement for mutual protection would be a thousand times more effective in preventing the disastrous spread of a small fire, neglected, perhaps, for the reason that it was not on the land of the one who observed it.

In the turpentine belt or longleaf-pine region dry grass in the open woods is fired every winter to improve the grazing and to prevent fires later on during the turpentining season. In this region the custom of annual burning is more firmly established than in any other forest region. The problem of fire protection is made more difficult by the fact that natives hold to the custom as an hereditary right, lumbermen are indifferent, and turpentine operators care only to protect their four crops of turpentine in the easiest manner.

The problem resolves itself into a remedial campaign of education relative to damage by forest fires, enactment and enforcement of suitable state fire laws, creation of an organization of state fire wardens, and guards who will do something, and persistent personal effort of each state forester in stimulating public sentiment against setting fires in woodlands.

If enough interest can be aroused, owners of adjacent timber lands may be prevailed upon to band together for fire prevention and protection, each defraying his proportional share of the expense.

Fire protection in the Lake States.—With the possible exception of the southern pine region, there exists nowhere a greater apathy regarding forest fires and less real effort to prevent them than in the Lake States—Minnesota, Wisconsin, and Michigan—this in the face of the fact that a major part of the property fire loss and more than three-fourths of the deaths have occurred in this region. Disaster, such as that of 1908, does not seem to offset indifference and ignorance; even where state laws are good, they are useless unless enforced and supplemented by the efforts of landowners.

In the Lake States fires can for the most part be completely suppressed with reasonable expense. The most destructive fires always occur in cut-over areas of slash, and such fires may in a high wind spread into the crowns of young pine and balsam. So great is the danger of fire after logging that if fire protection is to be attempted, the tops must be burned.. This can be done during the skidding, even with snow on the ground, by piling the tops on fires as the swamping progresses; or the tops can be burned early in the spring before the ground is dry enough for fire to run.

With the slash burned, subsequent fires will take the form of low surface fires consuming the dried grass, weeds, and small brush of from one to three years' accumulation. These fires must be absolutely prevented if a second crop of timber is to be grown.

To do this the owner must resort to two measures to supplement the state fire laws, namely, the employment of fire patrols and the construction of fire breaks.

Streams, roads, and even trails may be used as fire breaks. A high wind will drive fires across the best fire breaks, but small fires frequently burn out along a break or road. The purpose of breaks should be, not to mechanically prevent the crossing of a fire, but to give the fire patrol a chance to fight an advancing fire successfully.

The worst fires may be stopped along a fire break by back firing. It is, therefore, to supplement the efforts of the fire fighters that breaks should be made.

Where natural features or roads are absent fire breaks can often be cheaply constructed. On the sandy plains of the Michigan state forest reserves strips 20 feet wide are fully plowed, with no effort to grub the stumps, at a cost of $20 to $30 per mile. The first plowing lasts two years without renewal.

In hard-wood forests or white pine, with much underbrush, plowing is expensive and inefficient. Here two parallel strips may be cleared a few feet wide by brushing and raking, and the space between burned, the width being from 25 to 100 feet, according to the danger. Railroads should burn a strip along their tracks as wide as their right of way, and 200 feet would be safer.

A mounted ranger can patrol a township of land and is often called on to guard much larger areas. If on foot, there should be two and preferably three or four men to a township, depending on the value of the property to be protected. The larger and more compact the holding, the smaller will be the expenses per acre for fire protection.

For fire fighting in most of the Lake State regions water is not available. The long-handled shovel and the use of sand will be effective against ground fires. For the direction of a force of fire fighters, and for the subsequent handling of back fires whenever they become necessary, a ranger with some experience is indispensable. The employment of one or more of such men will have an educative and restraining influence in the matter of careless setting of fires. The total cost of fire protection by these means should not exceed 10 cents per acre annually on tracts of 10,000 acres or more.

Fire control in the West.—In the western part of the country, three different types of forest roughly differentiate the methods of fighting. These types may be described as the Rocky Mountain, the Pacific Northwest, and the California.

The Rocky Mountain region.—In the Rocky Mountains fire is much dreaded from the beginning of the dry season until the first storm that presages winter. Because of the character of the country it is particularly hard to locate a fire that is started. The column of smoke that appears to be just over the first ridge may prove to be many miles away past peaks and canyons. Where a fire gets started and it is impossible to extinguish it, as is generally the case, all effort should be centered on confining it to the smallest possible area, or to the area containing the least valuable timber or upon which the least damage will be done. It is practically impossible to extinguish a fire of any extent by the application of water, and wholly impossible to beat out one, as in the case of a grass or prairie fire. The only effective method in this region is trenching, which consists in the removal of all duff and litter down to the mineral soil, in a strip about two feet wide. It is, in effect, ditch digging, which may be done rapidly and with comparative ease by the use of shovels, on soil covered only with humus and free from brush and rocks. Upon ground covered with huckleberry brush and other similar growths, and where the surface is rock strewn, the task becomes slow, tedious, and difficult, and the shovel must be supplemented by the mattock and pick.

To make trenches immediately adjacent to the fire front is worse than labor wasted. It is unnecessarily hard on the fire fighters because of the heat and the danger from falling trees. Moreover, these trees falling across the trench carry the fire beyond it, and there is always the possibility of overlooking particles of burning refuse and limbs that will carry the fire ahead. The location of the trench then becomes a vitally important point, and one to which the man in charge must give his attention at all times. Fortunately, the wind can usually be depended upon to come from a definite direction during the daytime, with a lesser opposite motion at night, beginning about sunset, and not reviving until about 10 in the morning of the next day. No matter what the time of the day may be, the trench must be laid enough ahead so that the fire may nearly reach but not cross it at the time the wind falls and the air currents change in the evening. Then, if the plans have been correctly laid and all dead trees that might fall across it have been cut, all will be well when evening falls. The wind will be down to a mere breeze which bears against the fire which is now burning nearly up to the trench. Back fires should then be set to all inflammable material immediately along the trench on the side toward the fire. Close watch should be kept that the fire may not get back across the trench; carried by the night breeze, it burns slowly toward the main fire. The two meet and the hard work is over.

Trustworthy men should be left to make their camp and stay with the fire that is inside the segregated area. A patrol of several days or even weeks is necessary so that a passing wind shall not carry embers over the line to start fires anew.

While the fires in the Rocky Mountain region are usually termed ground fires, it is a fact that within a fire area the crowns of nearly all trees are burned, and the shooting of the fire into the air and the burning of a large crown are fraught with serious possibilities of danger. A sharp lookout must always be kept, and in nearly every case a patrol must be maintained far beyond the trench construction to make sure that sparks and brands do not ignite the forest ahead and thus put the fires behind the fire instead of in front of it.

Fire control in the Pacific Northwest.—In the Pacific Northwest forest fires seldom travel with great rapidity, because the trees are less resinous than in other regions, but the luxuriant growth and great accumulation of duff and fallen wood makes them exceedingly difficult to extinguish. The monetary and economic loss is great because of the density and value of standing timber.

Even more than elsewhere is care with small fires of the greatest necessity, for the deep layer of combustible material on the ground may hold them for weeks or months until favorable conditions of wind and dry weather fan them into destructiveness. It too commonly happens that the arrival of such conditions late in every summer not only increases the danger from fires started while they prevail, but brings about the spreading beyond control of innumerable small fires which have been smouldering unattended because not considered dangerous under previous conditions when they could have been put out with small effort.

Camp fires should never be built against trees, logs, or rotten wood, which may remain burning unknown when the camp is left. Fires for clearing land should never be set during the dangerous season without the permit required by law and careful observance of its stipulated safeguards. Such fires set before the close season should be entirely extinguished or brought under complete control before the close season begins. Especially should all possible communication of smouldering fire from the burned area be prevented by the cutting of standing dead trees within it and the clearing of an adequate fire line around its edge. Accumulations of débris near cabins, logging camps, roads, and railroads should be burned at safe times in spring or fall, under the foregoing precautions, so they may not feed accidental fires during dry periods. Railroads or logging engines operating without proper spark arresters should be reported to the state authorities.

The tenacity of fires in the punklike ground cover is peculiar to this region. A fire starting in June may burn till Christmas in an area of one-fourth of an acre if the season is wet, but if a dry spell comes it spreads with great rapidity. There are thousands of such fires every year which nobody bothers with because they look so harmless, but when the right season comes the whole country burns up.

California.—Methods of fire protection and fire fighting in California do not differ materially from those in any other part of the West, except that protection must be more thorough and fighting must be done more quickly on account of the extraordinary dryness of the forest and the immense financial interests at stake. The long, hot summers, often without a drop of rain from May until November, turn the ground cover and underbrush into the most inflammable kind of material, and fire, once started, leaps along with amazing rapidity. This is especially true in the southern part of the State. Here the rich irrigated citrus lands are wholly dependent for their water supply on the brush-covered mountains from which the streams come. The chaparral of these slopes is so dense, so high, so dry, and so altogether impenetrable that when a fire once gets a good start it is almost impossible to control it. More than that, a man's life is in danger if he fails to keep at a safe distance.

The best protective measure is to make a network of trails, roads, and fire lines so that men can get about easily to watch for fire and get to it quickly when it starts; then during the danger season keep a lot of men constantly moving about the mountains ready to extinguish the little fires just as soon as they start; and give them a good telephone system by which to summon help when needed. These men must be professional fire fighters and know their business.

The best results in fighting forest fires will never be obtained until the whole thing is organized. This means hearty cooperation between the Federal Government, the several States, the counties, cities, corporations, and private owners; it means good laws, vigorously carried out, and it means the expenditure of money, a great deal of it.

(2) LEGISLATIVE MEASURES.

Practically all the States have laws fixing civil and criminal liability for damage done by the careless or malicious setting of forest fires. Recourse to these laws is, however, rare even in the States where the most advanced forest policies have been adopted. In the South laws of this kind are absolutely ignored. A strict enforcement of existing laws would go far toward removing the existing ignorance and indifference, and would, after a short time, render further prosecutions for the most part unnecessary.

Of great value, where properly enforced, are the laws prohibiting the setting of brush or fallow fires during certain seasons of the year, or allowing of such burning only upon the issuance of a special permit by a duly authorized officer, the burning to be done at such time and under such conditions as will not endanger neighboring forest property. Laws of this kind have been enacted in a number of the more progressive States. The proper enforcement of laws of this kind in the East and Middle West would prevent the occurrence of from one-third to one-half of the fires which occur under present conditions. In a letter to the forester in 1904, Col. W. F. Fox, of the New York state forest, fish, and game commission, said, referring to the New York fire law:

> I attach the most importance to the section of our law forbidding the farmers from burning brush or fallows in certain months of the year. Since the fires of a year ago we have enforced this law strictly in regard to the infliction of penalties for its violation. By continuing these prosecutions faithfully whenever a farmer burns his fallow out of season, we can undoubtedly eliminate entirely this prolific source of evil.

Nearly all the States have statutes requiring the use of efficient spark arresters on railroad locomotives. In general, however, the enforcement of these laws has been exceedingly lax, and in many cases engineers have not hesitated to remove the screens or to punch them full of holes when the presence of the screens began to interfere with the draft of the locomotive. Many railroad companies equip their locomotives with spark arresters, not because they are required to do so by state law, but in order to avoid civil suits for damages. This is the most effective weapon to compel observance of the law.

Many of the States also have laws requiring the clearing and annual burning of strips along rights of way. In only a very small number of cases is any attention paid to these laws. Strict enforcement, in connection with the use of efficient spark arresters, would bring about a great decrease in the number of forest fires along rights of way.

The great difficulty with laws such as those mentioned is that they are useless unless means are provided for their enforcement. This brings up the last and most important of the legislative measures for the prevention and control of forest fires, namely, the provision for an executive force charged with the duty of administering the laws. Many of the state forest and fire laws look exceedingly well on paper, but are totally inadequate to meet existing conditions, simply because inadequate machinery or none at all is provided for their enforcement. It should be fully recognized that it is cheaper to prevent forest fires than to fight them. The Federal Government has set the example by the establishment of a system of patrol on the national forests under the supervision of the Forest Service. Wherever possible, similar action should be taken by the States for the protection of state and private holdings from destruction by fire. There are several features which are essential to a good state fire law. In the first place an executive head should be provided. This should be a man who is thoroughly familiar with fire problems and who is intensely interested in the work. In some States this position is very advantageously combined with that of state forester; in others the two are kept separate, the firewarden being a nontechnical man. A good salary should be paid in order to secure a competent man. Political appointments should especially be avoided.

The second essential is the appointment of local firewardens. In most of the States where the appointment of firewardens is provided for this office has been combined with that of some township official, usually that of supervisor. It is believed, however, that the better policy is to appoint as firewardens the best men available and to make the positions permanent. Township officials, as a general rule, have a brief tenure of position, owing to the popular belief in rotation of office. In many cases also the town officials are apt to be petty politicians who are illy fitted for the important duties of fire protection and the management of large bodies of men. On the rolls of the State of New York are men who have served as firewardens over twenty years. Under this system they acquire an experience not only in fighting fire but in the exercise of judgment, the handling of men, and the keeping of the necessary accounts with the town and State. By confining appointments to property holders and influential citizens—men of well-known integrity—there is no need to fear that the firewardens will start fires to provide themselves with employment. They are too much interested in keeping down taxes in their respective towns to furnish any basis for this fear.

Without exception firewardens receive payment for time actually spent in fighting fire. Whether they should in addition receive a fixed salary to cover such duties as making reports and keeping records is open to question. Col. W. F. Fox, of the New York state forest, fish, and game commission, states:

> We do not find it necessary to pay the firewardens any fixed salary, large or small. We have had no difficulty in getting good men who were willing to serve without pay except for time and services actually rendered. As a rule our firewardens are well-to-do people who have lucrative employment the year round and do not need any compensation except for such time as when they are obliged by circumstances to give attention to the work. This is fortunate, because we have so many forest towns in our State that a salary list of this kind would be so burdensome that the taxpayers would complain. This would be the case especially in the years during which no fires occur.

On the other hand, Prof. F. Roth, forest warden for the State of Michigan, states:

> Even a forest warden should receive some pay, independent of whether he fights fire or not, at least enough to justify his attending to such duties as making reports and doing a certain amount of patrol work.

This plan has been put into effect in New Jersey, where township firewardens receive $20 and the district firewardens $10 annually, in addition to the per diem compensation allowed for time actually employed in fighting fire. The New Jersey plan has been in effect but a short time, so there has not been sufficient opportunity to demonstrate whether or not it is superior to the plan in effect in New York.

The great difficulty with practically all the firewarden systems, as at present in effect, is that they do not make adequate provision for the prevention of fires. In many cases the laws, if carried out, would provide a force to fight fires after they are once started. In practice, however, a firewarden is seldom informed concerning a small fire, so that in most cases he does not begin work until the fire has reached such proportions that it becomes a costly task to put it out. What is needed in forest regions is a system of paid patrol during the fire season. Small beginnings along this line have been made in several of the States, but they are almost entirely inadequate to meet the situation.

(3) EDUCATIVE MEASURES.

These are of primary importance, because it is through them that the adoption of administrative and legislative measures is secured. The most effective is the dissemination of information concerning the causes and effects of forest fires, and the methods by which they may be prevented or controlled. The almost total lack of accurate information concerning the loss due to forest fires is a very serious handicap to the efficacy of this method. Were the extent of the damage in its various forms once fully realized the public could not fail to be aroused to the point of taking decisive action.

On the ground, a very effective measure is the posting of fire notices at frequent intervals through the forest, particularly at camping places and at points of entrance and departure of travelers. These notices should be printed on cloth or tin, or be in the form of signs painted on wood. Cloth signs are usually about 12 by 14 inches in size and are ordinarily tacked on trees. They should be made to attract attention by the proper use of large type. Experience has shown that better results are obtained where cooperation is requested than where threats are used. Information should be given as to existing state or federal laws, and a brief statement made as to the reasons why the prevention of forest fires is desirable. The fire notice adopted by the Forest Service for use on the National Forests was designed to fulfill these requirements. The following is a copy:

FOREST FIRES.

The great annual destruction of forests by fire is an injury to all persons and industries. The welfare of every community is dependent upon a cheap and plentiful supply of timber and a forest cover is the most effective means of preventing floods and maintaining a regular flow of streams used for irrigation and other useful purposes.

To prevent forest fires Congress passed the law approved May 5, 1900, which—

FORBIDS SETTING FIRE TO THE WOODS, AND FORBIDS LEAVING ANY FIRES UNEXTINGUISHED.

This law, for offenses against which officers of the Forest Service can arrest without warrant, provides as maximum punishment—

A fine of $5,000 or imprisonment for two years, or both, if a fire is set maliciously, and a fine of $1,000 or imprisonment for one year, or both, if fire results from carelessness.

It also provides that the money from such fines shall be paid to the school fund of the county in which the offense is committed.

The exercise of care with small fires is the best preventive of large ones.—Therefore all persons are requested—

1. Not to build larger camp fires than are necessary.
2. Not to build fires in leaves, rotten wood, or other places where they are likely to spread.

3. In windy weather and in dangerous places to dig holes or clear the ground to confine camp fires.

4. To extinguish all fires completely before leaving them, even for a short absence.

5. Not to build fires against large or hollow logs where it is difficult to extinguish them.

6. Not to build fires to clear land without informing the nearest officer of the Forest Service, so that he may assist in controlling them.

This notice is posted for your benefit and the good of every resident of the region. You are requested to cooperate in preventing its removal or defacement, which acts are punishable by law.

JAMES WILSON,
Secretary of Agriculture.

(D) RESULTS ACCOMPLISHED.

(1) BY THE FEDERAL GOVERNMENT.

(*a*) NATIONAL FORESTS.

The increase in the efficiency of the national forest administration from year to year is strikingly shown by a comparison of the figures for area and value of timber destroyed during 1905, 1906, and 1907, as shown in the accompanying summary. The figure for 1907 was 42 per cent of that for 1906 and but 31 per cent of that for 1905. The percentage of total area burned over decreased from 0.66 of 1 per cent in 1904, before the Forest Service administration began, to 0.31 of 1 per cent in 1905; 0.094 of 1 per cent in 1906; and 0.14 of 1 per cent in 1907. The increase in area in 1907 is compensated for by the fact that all but 29,365 acres were grass fires, which destroyed no timber, while in 1906 the area of merchantable timber burned over was 52,374 acres. Thus in 1906 the merchantable forest burned over represented but one twenty-third of 1 per cent of the entire forest area, while in 1907 it was but one fiftieth of 1 per cent. These results have been brought about by the gradual increase in the number as well as in the efficiency of the rangers.

That the force is still much too small has been clearly demonstrated during the fire season of 1908. The season has, in general, been an exceedingly dry one, and fire losses over the entire country have been greater than at any time for many years. The expenditure of approximately $50,000 for fire fighting on the national forests has been necessary, in addition to salaries of forest officers under appointment, as contrasted with less than one-tenth of that amount during the preceding year. While the fire losses have been much heavier than during any other year since the forest service administration began, yet they are infinitesimal as compared with what was saved. It is estimated that of the 167,992,208 acres in the national forests, 75,000,000 acres contain saw timber of commercial size. The stand of timber on this area is estimated at nearly 400 billion feet board measure. At the average rate of $2.50 per M stumpage, the timber on the national forests thus has a value of $1,000,000,000. The wisdom of spending a reasonable amount of money for the protection of this vast property of the people can not be questioned.

The following tables show fire losses on the national forests since 1902, so far as statistics are available from the Forest Atlas:

Area of national forests in the United States, exclusive of Alaska and Porto Rico, burned over from 1904 to 1907, inclusive.

[Statistics from Forest Atlas and Boundaries Record.]

Calendar year.	Area of forests on December 31.	Total area burned over.	Percentage of forest area burned.	Area of merchantable forest burned.	Percentage of entire forest area represented by merchantable forest burned.	Value of timber destroyed.
	Acres.	*Acres.*		*Acres.*		
1904	58,052,064	388,872	0.66	....	....	....
1905	92,735,625	279,592	.31	....	....	$101,282
1906	122,178,541	115,416	.094	52,374	0.043	76,183
1907	149,869,614	212,850	.14	29,365	.02	31,590

Fires in the Rocky Mountain region in 1902.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
Colorado:			
Battlement Mesa, 807,560 acres	400	15,000	$50
Pikes Peak, 184,320 acres	(a)	....	....
South Platte, 683,520 acres	3,033	399,000	1,251
White River, 970,880 acres	700	120,000	650
Idaho:			
Bitter Root, 3,308,400 acres	330	20,000	20
Priest River, 645,120 acres	(b)	....	....
Montana:			
Bitter Root, 691,200 acres	1,181	575,000	430
Gallatin, 40,320 acres	....	....	....
Highwood Mountains	....	....	....
Lewis and Clark (N.) 1,428,480 acres	445	175,000	75
Lewis and Clark (S.) 3,242,240 acres	432	2,049,000	3,008
Little Belt Mountains, 45,080 acres	....	....	....
Madison, 736,000 acres	....	....	....
Wyoming:			
Big Horn, 1,216,960 acres	101	....	....
Medicine Bow, 420,584 acres	56,700	20,100,000	20,100
Yellowstone, 7,810,600 acres	32,000	991,500,000	991,500
Total	95,322	1,014,953,000	1,017,174

[a] No damage.

[b] Not estimated.

Fires in the Rocky Mountain region in 1903.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
Colorado:			
Battlement Mesa, 807,560 acres	(a)	....	....
Pikes Peak, 184,320 acres	60	45,000	$60
South Platte, 683,520 acres	(a)	....	....
White River, 970,880 acres	(a)	....	....
Idaho:			
Bitter Root, 3,308,400 acres	814	150,000	4,875
Priest River, 645,120 acres	2¼	15,000	10
Montana:			
Bitter Root, 691,200 acres	82	45,000	55
Gallatin, 40,320 acres	(a)	....	....
Lewis and Clark (N.), 1,428,480 acres	166	210,000 [b] 3,800	315
Lewis and Clark (S.), 3,242,240 acres	679	15,000	15
Little Belt Mountains, 45,080 acres	175	10,000	10
Madison, 736,000 acres	(a)	....	....
Wyoming:			
Big Horn, 1,216,960 acres	(a)	....	....
Yellowstone, 7,810,600 acres	111	30,000	202
Total	2,059¼	520,000	5,542
		[b] 3,800	

[a] No damage.

[b] Cords.

Fires in the Rocky Mountain region in 1904.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
Colorado:			
Battlement Mesa, 807,500 acres	(a)		
Pikes Peak, 184,320 acres	(a)		
South Platte, 683,520 acres		3,000	$13
White River, 970,880 acres	(a)		
Idaho:			
Bitter Root, 3,398,400 acres	3,560	3,000,000	4,900
Priest River, 645,120 acres	1,000	950,000	1,850
Montana:			
Bitter Root, 691,200 acres	15,461	895,000 [b] 123,760	1,000
Gallatin, 40,320 acres	(a)		
Highwood Mountains	630		
Lewis and Clark (N.), 1,428,480 acres	11,874	25,000,000	25,000
Lewis and Clark (S.), 3,242,240 acres	362	100,000	100
Little Belt Mountains, 45,080 acres	(c)		
Madison, 736,000 acres	(a)		
Wyoming:			
Big Horn, 1,216,960 acres	302	250,000	1,000
Medicine Bow, 420,584 acres	(c)		
Yellowstone, 7,810,600 acres	2,511	1,530,000	1,064
Total	35,700	31,728,000	34,927
		[b] 123,760	

[a] No fires. [b] Cords. [c] No damage.

Fire report for calendar year of 1905.

[Compiled from reports of forest officers.]

Reserve.	Area burned.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
Alexander Archipelago	8,104	192,000	$10
Ashland	1		
Baker City	7	1,000	1
Bitter Root (Mont.)	2,647	285,000	275
Bitter Root (Idaho)	8,963	6,192,000	2,630
Black Hills	330		
Bull Run	1,245		
Cascade (N.)	2,620	306,000	785
Cascade (S.)	5,707	932,000	135
Chiricahua	2		
Cochetopa	400	202,000	202
Diamond Mountains	20,440	5,200,000	1,830
Gila	9,300	565,000	790
Gunnison	51		
Henrys Lake	600	3,000	6
Holy Cross	2,500	1,000,000	2,000
Klamath	9,584	3,280,000	1,700
Lake Tahoe	2		
Lassen Peak	3,140	245,000	85
Leadville	690		
Lewis and Clark (N.)	8,508	18,952,000	4,738
Lewis and Clark (S.)	25,609	42,893,000	10,540
Little Belt	310		
Madison	855	4,440,000	4,440
Medicine Bow	4,560	3,762,000	5,643
Minnesota	6,800		
Modoc	30	30,000	30
Mount Graham	43	10,000	10
Mount Rainier	110	1,084,000	518
Payette	2,300	725,000	912
Pecos River	610	20,000	40
Pikes Peak	763	210,000	85
Plumas	3,500	1,800,000	1,154
Prescott	5		
Priest River	11,009	23,360,000	27,320
Salt Lake	80	5,000	10

Fire report for calendar year of 1905—Continued.

Reserve.	Area burned.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
San Bernardino	3,972	90,000	$270
San Francisco Mountains	79	25,000	75
San Gabriel	25	1,000	1
San Isabel	11	3,000	3
San Jacinto	140	125,000	125
Santa Barbara	8,019	....	....
Santa Rita	9,460	50,000	50
Sawtooth	19,061	5,500,000	8,250
Sierra (N.)	79,083	5,780,000	6,333
Sierra (S.)	9,659	930,000	1,111
Stanislaus	2	....	....
Trinity	3,842	16,465,000	10,864
Uinta	300	254,000	744
Warner Mountains	19	25,000	38
Washington (E.)	756	978,000	978
Washington (W.)	4	4,000	3
Weiser	2,145	4,400,000	4,350
Wenaha	1,420	2,130,000	2,115
White River	10	....	....
Wichita	17	....	....
Yellowstone (Abs.)	1	2,000	3
Yellowstone (W. R.)	2	11,000	11
Total	279 592	152,557,000	101,282

National forest fire statistics for 1906.

[Compiled from supervisors' annual fire reports by E. A. Zeigler; reports cover forests with an area of 97,000,000 acres.]

1. Total area burned over, 115,416 acres, twelve one-hundredths of 1 per cent of 97,000,000 acres reporting.

2. Merchantable area burned over, 52,374 acres.

3. Amount of timber destroyed, 101,970,000 board feet, three one-hundredths of 1 per cent of estimated stand on forests (350,000,000,000 feet).

4. Value of timber destroyed, $76,183.

7. Cause of fires:

	Number.
Railroad locomotives	303
Campers	292
Lightning	261
Incendiary	24
Clearing and brush burning	15
Hunters	13
Herders	7
Indians	5
Miscellaneous	17
Unknown	196
Total	1,133

1907.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
Arizona:			
Baboquivari	(a)	....	....
Black Mesa (N.)	556	98,000	$86
Black Mesa (S.)	(a)	....	....
Chiricahua	11,500	1,150,000	920
Dragoon	(a)	....	....

[a] No fires.

1907—Continued.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
Arizona—Continued.	*Acres.*	*Board feet.*	
Grand Canyon (N.)			
Grand Canyon (S.)			
Huachuca			
Mount Graham		432,000	$800
Pinal Mountains	350	5,000	16
Prescott	8		
San Francisco Mountains	23	3,000	1
Santa Catalina	1,149	68,000	157
Santa Rita	2		
Tonto	(a)		
Tumacacori	30	15,000	15
	(a)		
Total	13,618	1,771,000	1,996
California:			
Diamond Mountains			
Inyo	7	5,000	10
Klamath	(a)		
Lassen Peak	265	108,800	79
Modoc	6	500	10
Monterey	(a)		
Pinnacles	42		
Plumas	(a)		
San Bernardino	221	252,000	195
San Gabriel	1,047	20,000	30
San Jacinto (see Trabuco Canyon)	420	53,000	64
San Luis Obispo			
Santa Barbara	26,177		
Shasta	1,832	75,000	130
Sierra (N.)	37	82,600	94
Sierra (S.)	5,000	164,000	147
Sierra (E.)	8,941	2,000,000	5,870
Stanislaus	(a)		
Stony Creek	3,763	1,200,000	1,637
Tahoe	1,154	75,000	300
Trabuco Canyon (unclassified 49)	381	15,000	15
Trinity	25,000		
Warner Mountains	767	57,000	
	(a)		
Total	75,060	4,107,900	8,601
Colorado:			
Battlement Mesa			
Cochetopa	(a)		
Fruita			
Gunnison	(a)		
Holy Cross	23		
La Sal. (See Utah)			
Las Animas			
Leadville	5	1,500	6a
Medicine Bow			
Montezuma	7	9,000	18
Ouray	625		
Park Range	(a)		
Pikes Peak			
San Isabel	627	82,000a	165
San Juan			
Uncompahgre			
Wet Mountains	75	10,000	20
White River	6	6,500	16
Total	1,368	109,000	225
Idaho:			
Bear River. (See Utah)			
Bitter Root			
Bitter Root (Div. 10)	460	123,000	145
Big Hole. (See Montana)			
Caribou			
Cabinet. (See Montana)	(a)		
Cassia			
Coeur d'Alene and Palouse	(a)		
Henrys Lake	1,676	1,215,000	3,084
Kootenai. (See Montana)	1,730	2,000a	7
Lemhi (N.)			
Lemhi (S.)	3		
Palouse (included in Coeur d'Alene)			
Payette	303	1,810,600	2,713

a No fires.

1907—Continued.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
Idaho—Continued.			
Port Neuf		1,000	$3
Pocatello		1,000	3
Priest River. (See Washington)			
Raft River	(a)		
Salmon River	(a)		
Sawtooth	450	552,000	675
Weiser	7	7,000	7
Yellowstone		1,000	2
Total	4,629	3,712,700	6,638
Kansas:			
Garden City	38,400		
Total	38,400		
Montana:			
Big Belt			
Big Hole (Anac. Div.)	(a)		
Big Hole (N.)			
Big Hole (S.)	(a)		
Bitter Root	6		
Cabinet (N.)		600	1
Cabinet (S.)	120	55,000	112
Crazy Mountains			
Elkhorn			
Ekalaka			
Gallatin			
Helena			
Hell Gate (E.)	(a)		
Hell Gate (W.). (See Bitter Root, Mont.)			
Highwood Mountains	(a)		
Kootenai			
Lewis and Clark (N.)	23	5,000	5
Lewis and Clark (S.)	28	43,000	16
Little Belt		700	2
Lolo	132	100,000	125
Long Pine			
Little Rockies			
Madison	(a)		
Missoula			
Otter	1	100	3
Pryor Mountains	(a)		
Snowy Mountains	(a)		
Yellowstone (Shos.)			
Yellowstone (Abs.)	40		
Total	350	204,400	263
Nebraska:			
Dismal River	51,200		
Niobrara	(a)		
North Platte	(a)		
Total	51,200		
Nevada:			
Charleston	5	3,000	6
Independence	(a)		
Monitor	(a)		
Ruby Mountains	(a)		
Tahoe. (See California.)			
Toiyabe			
Toquima	5		
Total	10	3,000	6
New Mexico:			
Big Burros	5		
Gallinas			
Gila (N.)			
Gila (S.)	6,014	90,000	305
Guadalupe	100	100,000	50
Jemez	3	7,000	13
Lincoln	351	500	1
Las Animas			
Magdalena	5	1,000	2
Manzano	10		

[a] No fires.

1907—Continued.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
New Mexico—Continued.	*Acres.*	*Board feet.*	
Mount Taylor			
Pecos River			
Peloncillo	6		
Sacramento	2,000		
San Mateo	45	6,000	13
Taos			
Total	8,539	204,500	374
Oklahoma:			
Wichita	13,840		58
Total	13,840		58
Oregon:			
Ashland			
Blue Mountains (W.)	60	15,000	30
Blue Mountains (E.)	181	62,000	109
Bull Run	6	10,000	15
Cascade (N.)	(a)		
Cascade (S.)	213	105,000	108
Coquille	662	200,000	188
Fremont			
Goose Lake	220	28,000	33
Heppner	125	14,000	180
Imnaha	(a)		
Siskiyou	12	13,000	20
Tillamook	113	160,000	320
Umpqua	(a)		
Wenaha. (See Washington.)	(a)		
Total	1,592	607,000	1,002
South Dakota:			
Black Hills			
Cave Hills	1,742	237.700	735
Short Pine	(a)		
Slim Buttes	(a)		
	(a)		
Total	1,742	237.700	735
Utah:			
Aquarius			
Bear River	(a)		
Beaver		2,000	7
Dixie	(a)		
Fillmore	(a)		
Fish Lake			
Glenwood	(a)		
Grantsville	(a)		
La Sal	(a)		
Manti	(a)		
Monticello	(a)		
Payson	(a)		
Raft River. (See Idaho)	(a)		
Salt Lake	(a)		
Sevier	28		
Uinta	(a)		
Vernon	(a)		
Wasatch	(a)		
	(a)		
Total	28	2,000	7
Washington:			
Colville			
Olympic	(a)		
Priest River		15,002,000	7,500
Rainier	2	7,500	7
Washington (Wenatchee)	1,840	2,705,000	2,735
Washington (W)	107	1,101,000	358
Washington (Chelan)	64	217,000	437
Wenaha	82	7,000	14
Total	2,095	19,039,500	11,051

a No fires.

1907—Continued.

Reserve.	Total area burned over.	Timber destroyed.	
		Amount.	Value.
	Acres.	*Board feet.*	
Wyoming:			
Big Horn	360	1,000,000	$600
Bear Lodge			
Black Hills. (See South Dakota)			
Caribou. (See Idaho)			
Crow Creek	(a)		
Medicine Bow	5	7,600	14
Sierra Madre	1		
Uinta. (See Utah)			
Yellowstone (Teton)	9	18,600	16
Yellowstone (W. R.)	4	1,200	2
Total	379	1,027,400	632
Alaska:			
Afognak	(a)		
Alexander Archipelago	(a)		
Chugach	(a)		
Tongass	(a)		
Total			
Porto Rico:			
Luquillo			
Total			
Grand total	212,850	31,026,100	31,590

[a] No fires.

Final fire statistics for 1907 for national forests (area approximately 150,000,000 acres).

[Compiled from supervisors' annual fire reports by E. A. Ziegler.]

1. Total area burned over, 212,850 [a] acres, or 0.14 per cent of 150,000,000 acres reporting.
2. Timbered area burned over, 29,365 [b] acres, 0.0002, or less than 0.007 per cent of the 450,000,000,000 feet board measure, estimated stand, on this area.
3. Amount of timber destroyed, 31,026,000 board feet.
4. Value of timber destroyed, $31,590.
5. Cost of fire fighting (exclusive of forest officers' salaries):

Labor	$4,259
Supplies	718
Total	4,977

6. Total number of fires reported:

Class A	845
Class B	280
Class C	181
Unclassified	49
Total	1,355

7. Causes of fires:

Campers	346
Railroad locomotives	273
Lightning	176

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[a] Large area burned over due to three large grass fires on Dismal River (Nebr.) national forest, 51,200 acres; Garden City (Kans.) national forest, 38,400 acres; Wichita (Okla.) national forest, 13,840 acres; total, 103,440 acres.

[b] Includes area of 11,500 acres in Chiricahua national forest, Arizona, reported as timber land, but only 100 board feet per acre were destroyed.

7. Causes of fires—Continued.

Donkey engines	65
Clearing land	34
Incendiary	19
Hunters	9
Herders	6
Miscellaneous	60
Unknown or not reported	367
Total	1,358

The Forest Service may justly pride itself upon this showing. The amount of hardship and self-sacrifice undergone by forest officers in order to achieve these results will never be known. The point is that rangers are stationed at convenient intervals throughout the entire forest area; that by their enforcement of the laws and regulations fires are for the most part prevented, but that when fires do occur they are discovered promptly and the necessary steps taken to extinguish them. Rangers are authorized to hire help and fight fire and to purchase necessary provisions. Rangers in adjoining districts and supervisors in adjoining forests cooperate with each other to prevent and control fire, and no effort is spared to prevent the destruction of the forest from this cause. The results already accomplished have clearly demonstrated the fact that destruction of forest property by fire may be almost entirely prevented by the adoption of a suitable system of patrol.

Probably the best example of cooperation betweeen the Federal Government, the State, and the counties in the prevention and control of forest fires occurs in southern California. Under the terms of the state forest law enacted in 1905 the state forester is authorized to maintain a fire patrol in times and localities of particular fire danger. Firewardens are appointed by the state forester, but their salaries and the cost of patrol must be met by the counties in which the patrol is maintained. The greatest danger from fire to the national forests in southern California is from the foothill region along the west boundary, outside the present limits of the forests. In the past these areas have in general been unprotected and great damage from fire has resulted, not only to the areas outside the forests, but to the forests themselves, from fires originating on the outside and burning across the forest boundary. During the past two years, however, a plan has been adopted for the cooperative patrol of a considerable portion of these foothill regions. The plan has been for the Forest Service and the county to provide an equal number of men for this patrol during the four months of greatest fire danger. The firewardens to be paid by the counties are appointed by the state forester. Under the law these appointments may be made, where required by public interests, whether the county concurs or not. In a number of cases the initiative has been taken by the state forester in this way with excellent results. The adoption of this plan has brought about a notable decrease in the number and severity of fires in the foothill region of southern California. Much also has been accomplished in the way of enforcing state fire laws by the general appointment of forest rangers as state firewardens.

Until the past year but little had been accomplished by the Federal Government in the way of cooperation with railroad companies for the prevention of fires on the national forests. That railroad locomotives have been one of the greatest menaces to the forest is unquestionable. That this is true has for the most part been due to two facts: (1) The absence or defective condition of spark arresters; and (2) the failure of the companies to take proper precautions against the spread of fire through the clearing of rights of way and the issuance to employees of proper instructions with regard to the control of such fires as are set by locomotives.

The first deficiency is gradually being remedied through the enforcement of state laws. With regard to the second, practically no steps have been taken outside the national forests, and there only during the past year, after the initiative had been taken by the Forest Service.

At the end of the calendar year 1907, 32 of the national forests in the United States were traversed by coal or wood-burning locomotives through timbered areas in which the railroad rights of way were in such a condition that effective measures were necessary for the protection of the forests from fire. To meet this need the matter was systematically taken up by the Forest Service and an attempt made to secure cooperative agreements with each of the roads operating in the 32 forests mentioned. Field examinations of the rights of way have been made by forest officers, and these reports have formed the basis of action. The details of cooperative agreements are being discussed with a number of railroads. Where cooperation can not be secured it is the policy of the service to sue the railroads for civil damages in every case where damage to the national forest occurs from fire due to the negligence or disobedience of law on the part of any railroad company.

The principal features of the proposed cooperative agreement are as follows:

1. The railroad company agrees to cut and remove all live and dead timber from a strip 250 feet in width on each side of the roadbed on all vacant government land and all lands owned by the company which are crossed by the roadbed within the exterior boundaries of the national forest, the work of clearing this strip to commence not later than a specified date and to be continued, until completed, with reasonable diligence.

2. The railroad company further agrees to clear such strips of all young growth, brush, and other inflammable material, and at all times during the life of the agreement to keep such strips clear of all inflammable material. The cutting of the timber and the clearing of the strips to be done at all times under the direction and to the satisfaction of the supervisor of the national forest in question.

3. The forester authorizes and permits the railroad company to enter upon such portions of said strips as lie upon vacant government land within the national forest, and to remove all live and dead timber and to appropriate the same without charge for the use or benefit of the railroad company.

4. The railroad company permits the forester to attach such telephone lines as may be needed for the proper protection of the national forest to telegraph or telephone poles of the railroad company along the right of way within or near the boundaries of the national forest, such attachments to be made in accordance with the instructions of the railroad company.

5. The railroad company agrees to adopt a system of notifying the forest officers of any fires discovered by train crews or other employes of the railroad company by warning whistles and by telegraph or telephone communication, such system to be approved by the officer in charge of the forest.

6. The railroad company agrees to furnish at all times at the request of any authorized forest officer a sufficient number of men to assist in fighting fire on or near the right of way, together with necessary tools and the subsistence required while so employed.

7. The forester further agrees to patrol the right of way of said railroad company, and so far as possible to aid in extinguishing fires on or near the right of way.

8. The forester further agrees to supervise the cutting of the timber and clearing of the strips before mentioned, provided that proper and necessary assistance is furnished by the railroad company.

9. The forester further agrees to construct and maintain sufficient telephone lines and to supply at proper points tools and other necessary equipment, sufficient for the effective fighting of fires on or near the right of way.

A good example of actual cooperation on the part of a railroad company occurred during the past summer. The Chicago, Milwaukee and St. Paul Railway Company is constructing a transcontinental railroad through the Cœur d'Alene National Forest, Idaho. Their right of way within the forest is 28 miles in length. Several thousand foreigners are employed upon this work, and during the season the danger from fire along the right of way was very great. An understanding was reached with this company this summer through which it cooperated with the Forest Service by establishing a fire-patrol force of 80 men along the right of way. These men were under the control of four civil engineers, who, before the fire season, had been engaged in construction work on the railroad. It was provided that these men, although in the pay of the railroad company, should be subject to the orders of the forest rangers in that district. As may be expected, a large number of forest fires originated from stragglers from the construction camps, and probably in some cases through the direct carelessness of the contractors and others engaged in construction work on the railroad. These fires were in every case attacked by the patrol force of the railroad and the rangers and were controlled and extinguished before any great damage was done. Had officers of this forest not been successful in securing the cooperation of the railroad company in this region it is probable that the extensive virgin stand of white-pine timber through which the railroad passes would have been completely destroyed.

(b) RESULTS ACCOMPLISHED ON MILITARY RESERVATIONS, NATIONAL PARKS, AND INDIAN RESERVATIONS.

On the military reservations there is very little destruction of timber by fire. The reservations are for the most part small and the proportion of commercial forest low. It is estimated that on all the military reservations there are but 72,964 acres of commercial forest. The estimated total stand of timber is 307,063,000 feet board measure. The presence of troops on or near each reservation makes it possible to extinguish promptly any fire that may occur. In some cases patrol is maintained to guard against forest fires. The timbered portion of the Fort Grant Military Reservation, Ariz., has been included in the Crook National Forest, and protection from fire is secured through the patrol maintained by the Forest Service. The same action has been taken with regard to the Fort D. A. Russell Wood and Timber Reserve, Wyo., now a part of the Cheyenne National Forest. The War Department reserves the right to make use of these areas for military purposes, but the grazing and timber and other business and the protection of these areas from fire are conducted by the Forest Service exactly the same as on other national forest land.

The efficiency of the methods adopted by the War Department for the protection of military reservations from damage by forest fires is shown by the following table. Only such reservations are listed as are reported to contain merchantable timber. The figures are from statements made by the respective officers in charge:

Name of reservation.	Area of reservation. Acres.	Area burned in 1907.	Method of prevention and control.
Arizona:			
Fort Grant	42,000	None	Forest Service cooperation.
Fort Huachuca	44,800	do.	Use of troops.
Florida:			
Fort Barrancas	2,700	do.	No steps necessary.
Cedar Keys	211	do.	Do.
St. Johns Bluff	117	do.	Do.
Georgia and Tennessee:			
Chickamauga and Chattanooga	6,362	do.	None.
Georgia:			
Fort McPherson Rifle Range	1,271	do.	Do.
Point Peter	1,100	do.	Do.
Illinois:			
Rock Island Arsenal	1,000	do.	Fire service.
Indiana:			
Fort Benjamin Harrison	1,997	do.	Daily observations.
Kansas:			
Fort Leavenworth	6,970	1,000 acres ($500)	Forester, range riders, daily patrol.
Maine:			
Fort Knox	124	None	Patrol in dry season.
Fort Levett	125	do.	Troops available.
Montana:			
Fort Missoula Wood and Timber Reservation.	1,577	do.	Occasional patrol from post 6 miles distant.
Fort Assinniboine	168,610	do.	Troops available.
New Mexico:			
Fort Bayard	13,780	do.	Judicious grazing.
New York:			
Fort Wadsworth	230	do.	Fire department.
West Point	2,556	do.	
North Carolina:			
Fort Caswell	2,325	do.	None.
Oregon:			
Fort Stevens	1,250	do.	Supervision of garrison.
South Dakota:			
Fort Meade	7,700	150 acres ($50)	Guard duty.
Virginia:			
Fort Hunt	197	None	Burning grass in fall.
Washington:			
Three Tree Point	640	do.	None.
Hoods Head	43	do.	Do.
Gig Harbor	78	do.	Do.
Port Defiance	638	do.	Guard by employees.
Nee-ah Harbor—			
West side	381	do.	None.
East side	398	do.	Do.
Washington Harbor—			
West side	475	do.	Guard by lessee.
East side	424	do.	None.
Challam Point	548	do.	Do.
Hope Island	200	do.	Guard by lessee.
Northern part of Whidby Island.	606	do.	None.

Name of reservation.	Area of reservation.	Area burned in 1907.	Method of prevention and control.
Washington—Continued.			
Deception Pass—	*Acres.*		
South side	630	None	None.
North side	550	do	Do.
Shaw Island	1,103	do	Guard by residents.
Lopez Island	1,311	do	Do.
San Juan Island	1,124	do	Do.
Fort Townsend	615	do	Guard by caretaker.
Tala Point	102	do	None.
Foulweather Point	485	do	Do.
Double Bluff	626	250 acres ($3,000)	Do.
Vashon Island	487	None	Do.
Protection Island (land opposite).	254	do	Do.
Fort George Wright	1,023	do	Patrol by soldiers.
Fort Ward	230	do	
Fort Flagler	906	do	Cleared strip.
Wyoming:			
Fort D. A. Russell Target and Maneuver Reservation.	36,800	do	Notices, Forest Service patrol.

On the national parks protection from fire is as complete as on the military reservations, according to the reports of the respective superintendents. The parks are in general much larger than reservations and contain a much greater area of merchantable forest. It is estimated that in all the national parks there are 2,540,000 acres of merchantable forest. The total stand of timber on this area is estimated at 10,717,000,000 feet b. m. Where danger from fire exists a regular patrol is maintained, and a sufficient body of troops is available to promptly extinguish any fire that may occur.

The following table shows results obtained along this line during 1907 on such national parks as are reported to contain merchantable timber. The figures are from statements submitted by the respective superintendents:

Name of park.	Area of park.	Area burned in 1907.	Methods of prevention and control.
California:	*Acres.*		
Yosemite	967,680	None	Guard by cavalry.
Sequoia and General Grant	172,165	do	Patrol, warning notices, road, trail, telephone, fire lines, tool stations.
Oregon:			
Crater Lake	159,360	do	Patrol.
Pennsylvania:			
Gettysburg	2,047	do	Guards, workmen, and tenants.
Tennessee:			
Shiloh	3,325	do	Annual ground fires.
Washington:			
Mount Rainier	207,360	do	Regular fire patrol (3 men during July, August, and September), 2 tool stations, warning notices.
Wyoming:			
Yellowstone	2,142,000	do	Daily patrol, troops and rangers, enforcement of park regulations, fire-fighting tools constantly accessible.

No statistics are available as to damage by forest fires on the Indian reservations. It is, however, known that these reservations have received immense damage from year to year, and that but little effort has been made to prevent the indefinite recurrence of such damage. Fires occurring near the agencies have in many cases been extinguished. No provision has, however, been made by Congress for a systematic patrol. Superintendents of Indian reservations have neither the authority nor the funds to employ men for fire fighting, and it is very difficult to get the Indians to voluntarily perform work of this kind. Under such circumstances, fires will inevitably occur in the future, as they have in the past, in the more remote and inaccessible regions. These fires usually owe their origin to carelessness, malice, or natural causes, and, as a rule, continue unchecked until they either burn out or are extinguished by rain.

Indian reservations are located in 14 States and Territories. It is estimated that there are in all the reservations 10,541,900 acres of merchantable forest, carrying a stand of 34,089,000,000 feet b. m. of timber. That adequate steps should be taken for the safeguarding and perpetuation of this vast property can not now be questioned. Undoubtedly a comprehensive system of protection and management should be adopted, based upon that now in use upon the national forests. A beginning along this line has already been accomplished by the cooperation of the Forest Service with the Indian Office during the past summer. On the Klamath and Coeur d'Alene Indian reservations the plan is in actual operation and will be carried on indefinitely so long as funds are available. Its extension to other forests is merely a matter of time.

The total area of the Klamath Indian Reservation, Oreg., is about 1,100,000 acres; of this, it is estimated that 700,000 acres are timbered. The question of cooperative protection arose during the summer of 1908, the Indian agent being unable to cope successfully with the several large fires which were burning on the reservation. After some correspondence, an understanding with the Indian Office was reached whereby 5 men were placed on patrol on the reservation under the direction of the supervisor of the Crater National Forest, whose headquarters are at Medford, Oreg. A fund of $2,500 was made available in the Indian Office to cover the salaries of these men during the fire season. An additional sum of $1,000 was made available to be expended by the Indian agent for fighting fire. Owing to the fact that several fires had gained great headway before steps were taken toward their extinguishment, the entire balance of the fire season was spent in fire fighting, with the result that the fires were brought under control and a vast amount of timber saved from destruction.

A similar plan was put into effect during the past summer on the Coeur d'Alene Indian Reservation in northern Idaho. This action was made necessary by the fact that two lines of railroad cross the reservation, thus endangering not only the timber on the Indian land, but also on the adjacent Coeur d'Alene National Forest. As in the case of the Klamath Reservation, a plan was adopted whereby three forest guards were placed on patrol under the direction of the supervisor of the Coeur d'Alene National Forest. Just as this plan was approved, occasion arose to test it through a severe fire on the Indian reservation.

On August 5 and 6 a forest ranger who was patrolling a district in the Coeur d'Alene National Forest some distance south of the Coeur d'Alene Indian Reservation, noticed considerable smoke drifting in from the country to the north of the national forest. On the 7th the smoke became so dense that the ranger left his district and traveled on horseback into the Indian reservation, where he discovered a large forest fire burning in valuable timber on the reservation. The reservation authorities at this time had no system of fire protection on their lands and nothing was being done to check the fire. The flames had a front of about 5 miles and were traveling rapidly before a strong wind through a dense forest of white and yellow pine, red fir, hemlock, and tamarack. Nearly a half-billion feet of merchantable timber was in imminent danger. Officers of this forest at that time had no authority to fight fires on the Indian reservation. The ranger, however, rightly judged that some action could be taken to save the government's property, and rode to St. Maries, the nearest telephone office. Upon telephoning to the supervisor of the national forest at Wallace, he was instructed to take in a crew of 20 men to the fire and return to St. Maries for instructions.

Meanwhile the forester was wired from Wallace that forest rangers were fighting fires on the Indian reservations, and instructions were requested. On August 8 the forester replied by wire, instructing the officers of this forest to extinguish the fire and to keep him informed by telegraph.

About 40 more men were accordingly gathered and dispatched to the fire, which was located in an inaccessible region. In order to get in camps and supplies for this large crew, it was necessary to construct several miles of trail, and the entire force was put on the fire within twenty-four hours after receiving final instructions from the supervisor at Wallace, and within another twenty-four hours the fire was practically under control.

The burned area was large and was covered with smoldering logs, stubs, and remnants of the fire. It was not possible to extinguish the fire within the burned area, and the efforts of the men were directed toward hastily constructing a trail or fire line around it and fighting the fire back on this line. For several days strong winds prevailed, and it was only by the greatest effort that the men were able to hold the fire within the burned limits. In some instances the fire leaped the barriers and more fire lines had to be constructed around newly burned areas.

The weather continued exceedingly dry, and it was nearly four weeks before it was possible to withdraw all the men. As this district was remote from the supervisor's office at Wallace, and the supervisor himself was constantly engaged in controlling the many fires on the national forest, it was difficult to provide means for promptly paying the men. Most of them were hastily secured from many sources and were penniless. In order to retain them it became necessary to devise means for promptly paying them for their services. Firewarden Ross of the State and Lumberman's Protective Association, who was stationed at St. Maries, volunteered to reimburse the men through orders drawn on the association, the account of the association to be, of course, later submitted to the Government for payment.

The cost of fighting this fire was approximately $4,500, of which nearly one-fourth was expended in supplies and equipment, the remainder being paid in wages.

Probably one-half billion feet of timber, valued at $2,000,000, were saved by controlling this fire. The great cost of fighting this fire is in contrast to those extinguished on the Coeur d'Alene National Forest, the average cost of which amounted to about $400 per fire. The difference is due entirely to the fact that there is on the Coeur d'Alene National Forest a system of fire patrol and protection, and fires in the forest were discovered and extinguished before they gained much headway. It is probable that at a cost not exceeding $2,000 a system of fire patrol could have been maintained on the Indian reservation which would have prevented the great damage done by this fire.

(c) RESULTS ACCOMPLISHED ON THE PUBLIC DOMAIN.

Of the unappropriated public domain outside of Alaska it is estimated that 4,448,400 acres are forest land, bearing a stand of 13,838,000,000 feet b. m. of timber. This area is so widely scattered, and is passing out of the hands of the Government at such a rapid rate, that its protection and administration would be impracticable even were there any provision for such a course. As a matter of fact, there are neither funds nor men available for this purpose, and absolutely no steps have been or are being taken to prevent the destruction by fire of timber on the public domain. In the States of Oregon, Washington, Idaho, Montana, Wyoming, and Colorado further additions to the National Forests are prohibited by law, except by act of Congress. Important bodies of commercial forest in the other States have either been included in National Forests, or are under temporary withdrawal, or else have been filed upon and are either patented or in process of becoming so. Under these conditions but little action on the part of the Federal Government is practicable along the line of fire protection. In some cases fires on the public domain adjacent to the National Forests are extinguished by forest rangers. This action is taken in every possible case where the National Forest is threatened. Owing, however, to the limited amount of money available for fire protection on the forests, but little protection to lands outside can be given by the Forest Service.

The unappropriated timber lands of the public domain are for the most part either in such small bodies or are situated so remotely from transportation that they offer but little attraction to the individual as an investment. In many cases they consist of isolated and widely scattered tracts of 40 or 80 acres, so that it is impracticable to secure a satisfactory timber and stone claim; in others the amount of timber on a possible claim is so small that it is not worth while to go to the expense of locating and filing; and in many instances the timber is so far distant from possible transportation or utilization that its location is not considered good business policy. It must be realized, also, that only a small percentage of the remaining public domain contains commercial forest, and that great expense and loss of time are involved in determining from the land office records what areas are still unappropriated and in making the necessary field examinations to ascertain which of these areas are timbered. These conditions are for the most part responsible for the fact that any of the timbered portion of the public domain still remains in the hands of the Government.

Not only is the timbered portion of the public domain rapidly passing into private ownership, but the danger from fire to the portion remaining is constantly increasing. The comparatively small isolated tracts are for the most part surrounded by private holdings of timber lands. Some of these lands have already been lumbered and others are being held for future cutting. On the lands which have not been lumbered there has until very recently been practically no attempt at fire protection. The lands of the public domain have received the same damage from fire that has been received by lands in private ownership. Where, however, privately owned lands have been lumbered the slash has been left on the ground, forming a fire trap, and the resulting damage from fire to adjacent uncut timber on the public domain has been very great. As lumbering proceeds on private holdings the damage to unreserved government timber lands will constantly increase, until practically all the timber on the public domain is either filed on or destroyed by fire.

(2) RESULTS ACCOMPLISHED BY STATE GOVERNMENTS.

As compared with the urgent need for adequate prevention and control of forest fires but little has been accomplished by state action. Many laws have been passed by the various States, which vary greatly among themselves, and many look well upon the statute books. Laws against the setting of fires are far from uniform, but in practically all cases they would be sufficient were they enforced. The fact is, however, that they are not enforced, and never have been in any State. The machinery for proper enforcement is wanting. If the owner or his agents catches a man setting a fire he can prosecute through the proper office, bring the case into court, and if he can get the jury to convict he can get the offender punished. It is, however, a matter between owner and court, and not one of proper police. This lack of protection has in general worked strongly against the holding of forest lands as a permanent investment. In many parts of the country areas that would otherwise have been held for future cutting or for a second crop have been cut clean because of the fear that if this action were not taken great loss would result from forest fires. Small areas of timber surrounded by cut-over lands have been considered as practically doomed and every effort made to get them lumbered before their destruction by fire.

Usually with the first code adopted by each State came laws (derived like the laws on forest trespass) dealing with the prevention of fires in forest and on prairies. Like the laws on trespass, these earlier efforts are simple, direct, and severe. Thus in Michigan as early as 1846 the law provided a penalty for willfully burning the woods of another amounting to as much as five years in State prison and a fine of $500. Quite early, and in some cases as parts of the first protective act, came provisions making the fighting of forest fires a special duty of the supervisor, the justice of the peace, or the highway commissioner or some other official, giving these officials power to call out the citizens and making it obligatory, under severe penalty upon the citizen, to obey summons and help in the fight against fire. The responsibility of the local authorities was thus clearly recognized at an early date. But there was a penalty prescribed only for the citizen and not for the officer, and so the officer found it to his political interest never to call people out.

Thus these laws (even more than the laws of trespass) remained dead letters. The difficulty of catching the evil doer, the ease of finding excuses in having to clear land, burn brush, cook food on camp fire, etc., and thus establishing some reason for the existence of fire; then, also, the matter of accident, the pipe, the cigar and match and torch all allowed in the forest at any time and season; the general permission of any one to travel, camp, hunt, and fish on other people's lands; all these made it practically impossible for the owner or his agent to bring the matter before court and secure conviction. And even if conviction could be had, it could have been of little value, for it is prevention of fire and not merely conviction of the "fire bug" that is wanted. And here, again, State, county, and town did nothing; and with this the sense of individual as well as corporate responsibility disappeared.

After a number of really great calamities, like the fires of 1871, 1881, and 1894 in the Great Lakes region, where hundreds lost their lives, thousands became homeless, and the damage ran well up in the millions, the situation became positively intolerable. The people clamored for action and the legislatures reluctantly enacted a series of laws, all of which were more or less modifications of the old fire-fighting laws already in existence, and collectively perhaps best termed "firewarden" laws. Like the trespass agents and game-warden laws, they are a makeshift, a duplication and interference in what should and could be the proper administrative body of the state government. The Michigan law, copied and modified from that of New York and Minnesota and again copied by Louisiana, etc., will illustrate this phase of state action. The State had a good, simple, though somewhat incomplete, forest-fire law, with a provision which made it the duty of the supervisor, justice, and road commissioner to call out the people and fight forest fires. Beyond this the State never spent a cent in protecting its second greatest natural resource and its second industry.

After enormous losses and years of agitation, the legislature, in 1903, made the state land commissioner a state forest commissioner (and this in spite of the fact that he already was a member of the state forestry commission), gave him power to appoint a state fire-warden. This man, with a salary of $500 per year, had authority over the supervisors, who were thus once more legislated into the fire-warden job. The earlier law was repeated in its main features, but the people were to receive pay for fighting fires, and the sum total spent in any one town should not exceed $50 in any one year, so that if $49 were once spent the people had to be sent home because there was no more money available. The state land commissioner himself in a public meeting declared that the law was not worth the paper it was printed on.

In 1907 the power of the land commissioner was transferred to the state gamewarden, who was made fire and game warden; the idea being, since this office was equipped by law with deputies scattered over the State, that it was a mere police body and thus would do better work. The fact is, however, that the law has fallen far short of accomplishing the desired end. During the past season (1908) fires have raged throughout the northern peninsula of Michigan and throughout the northern portion of southern peninsula. Although every supervisor was by law compelled to fight forest fires, as a rule no steps were taken until some town or especially valuable piece of private property was threatened with flames. In many cases action of this kind was taken too late, and as a result, in the State of

Michigan alone, loss was caused amounting to several million dollars. The same thing has been true in Wisconsin and Minnesota and many other States during the present season. In no State is there as yet an adequate system of protection against forest fires. Some of them have, however, been far more progressive than others and have made good beginnings along this line. The figures already quoted as to fire losses in some of the States, while neither complete nor accurate, are sufficient to demonstrate that even small expenditures of money and effort are well repaid by the results obtained. The difficulty has benn that in every case the expenditures of money and effort have been inadequate to meet the real needs of the situation.

The results of the forest-fire law in New Jersey illustrate to a remarkable degree the great saving brought about by protective measures. The law creating the forest park reservation commission was passed in 1905. A state forester is employed by the commission to superintend the general forest work. In 1906 provision was made for a state forest-fire service, under the direction of a state firewarden. The essential feature distinguishing the New Jersey plan from that adopted in other States is a paid organization which ignores property lines, covering the whole State and cooperating in every way possible with the owners of woodland, with the railroads, and with everyone having an interest in the suppression of fires. Township wardens receive $20 and district wardens $10 per year in addition to a per diem compensation for the time actually spent in fire fighting. The service now includes 300 firewardens, all of whom are expected to be on the lookout for fires and to summon help to extinguish one the moment it is discovered.

For this purpose they are authorized to require the services of any able-bodied citizen, under a penalty of $10. The expense of fighting fires is borne equally by the townships and State. The report of the state firewarden shows that for the year 1907 the loss from forest fires was less than one-tenth of that of any former year. This betterment in conditions can be traced directly to the activity of the firewardens. An important feature in this connection is the issuing of permits for burning brush. During the entire year no fallows, stumps, logs, brush, dry grass, or fallen timber may be burned in specified townships without the written permission of a firewarden. Such permission is refused where the burning would endanger any forest or woodland. In the past the burning of brush for the clearing of land has been the most fruitful source of forest fires. As a result of the new law, it is significant that but 7 per cent of the forest fires reported in 1907, whose origin is known, started from brush fires, whereas in former years the proposition was usually about one-fourth to one-third. The success of the state forest policy has been reflected in a general rise in the value of forest land. Rough woodland worth less than $1 an acre a few years ago is now held at $5 and more. Undoubtedly a part of this increase has been due to the general rise in land values, but there is no question but that the additional security from loss by fire under the new law has been an important factor in bringing about a realization of the revenue-producing possibilities of forest land.

New York is another good example of a State with fire laws which are progressive as compared with those of the great majority of the States. Even in New York, however, the law is inadequate to meet the situation. It is believed that the figures given in the first part of this paper for fire losses in the Adirondack and Catskill counties do not represent even approximately the true loss, to say nothing of the entire State. Much as has already been done, more remains to be accomplished, and unquestionably the facts justify the statement made by Col. W. F. Fox, superintendent of state forests, that without the system of state protection at present in force, fires would have been unchecked and would have resulted in the destruction of the entire forest. The state law provides for the appointment by the forest, fish, and game commissioner of a chief firewarden, to have supervision of town firewardens, visit and instruct them in their duties, and enforce the law as to fire districts in towns, and under the authority of the commissioner commence prosecutions for violations of law, to prevent forest fires. The law provides also for the appointment by the commissioner of a firewarden in every town having lands in the forest preserve, and the optional appointment of a firewarden in every town having lands that would become a part of the forest preserve if acquired by the State. Division of towns into two or more fire districts is provided for, to be guarded by district firewardens appointed by the town firewardens. In towns not included in the forest preserve the supervisor is made firewarden by virtue of his office. Firewardens, district firewardens, and laborers receive pay for time actually employed in fire fighting. All bills are approved by the firewarden and paid by the town in which the fire occurs. When approved by the commissioner one-half the amount is reimbursed the town by the State. During the present year there are 743 town and district firewardens under appointment.

The law provides also that whenever in the judgment of the commissioner it is necessary to protect the forests from fire he shall organize and, as long as necessary, maintain a fire patrol along the lines of railroad in forests in counties containing part of the forest preserve, and at such other places in such counties as the public interest requires, one-half the expense to be borne by the company and one-half by the State.

In order to reduce as much as possible the danger from railroads, each railroad company is required by law, on such part of its road as passes through forest lands or lands subject to fires from any causes, to cut and remove from its right of way along such lands, at least twice a year, all grass, brush, and other inflammable material. Patrol of tracks at the expense of the company is required, as is also the use of efficient spark arresters. Were these laws fully enforced immense good would result. That the desired protection has not yet been secured is shown by the fact that during the present season fires have raged all through the Adirondack and Catskill regions, it being claimed by the state authorities that 90 per cent of the fires have been caused by railroads. The State spent over $100,000 in fighting fire this year, but more than 1½ millions of dollars worth of property has nevertheless been destroyed. What is needed is the inclusion of further immense areas of nonagricultural forest lands in the state preserve, and the adoption of an adequate system of fire patrol at the expense and under the supervision of the State. The action most needed, however, is a law that will compel the adoption of electricity or oil as motive power for railroad locomotives through forest regions. The numerous disastrous fires that have occurred during the summer of 1908 have made this a distinct issue in New York, and the question is under investigation by the public service commission. Hearings have already been held, at which were present representatives of the railroad companies, as well as of a number of private and public interests and organizations desirous of securing adequate protection from forest fires.

As an argument in favor of the compulsory adoption of petroleum as fuel, the case is cited of the Raquette Lake Railway, which extends for 19 miles through the state forest from Clearwater to Durant. In granting the charter for this road the legislature stipulated that petroleum must be used for fuel. During the twenty years that this road has been in operation not a single fire has occurred along its right of way. The agitation for the general adoption of petroleum as fuel is met by the railroads with the statement that the Adirondack and Catskill roads are neither strong nor profitable, and that the expense of equipping the locomotives with oil burners would be almost confiscatory. It is contended also that many of the fires attributed to the railroads have in reality been set by the indiscriminate building of small fires for camping and pleasure purposes. The fact that some of the railroads in the Western States are changing from steam to electric power, utilizing local water powers for this purpose, was cited as an argument in favor of similar action in New York. This, however, was met by the contention that it would be impracticable to operate the roads by electricity secured from water power in the Adirondacks, as these water powers are insufficient during the dry season when railroad traffic is heaviest.

Along with New York and New Jersey, the States of Pennsylvania, Minnesota, Wisconsin, Maine, Maryland, Connecticut, Washington, and California are generally regarded as having done most to secure protection from forest fires. There is great variation as to the details of the plans in operation, the idea being generally adhered to, however, of firewardens under State supervision, paid locally, or in part locally and in part by the State. In general the same conditions prevail as have already been described for Michigan and New York with regard to the nonenforcement of laws and inadequacy of measures adopted.

In Maine, the legislature each year makes provision for the expenditure of $20,000, or so much thereof as may be necessary, to be used in fire fighting. In dry years this amount is absolutely inadequate, and the burden falls on the individual owners. In a number of cases fire-lookout stations are erected and equipped by the owners of wild lands, the State paying in each case the salary of the men assigned to the station, the owners bearing all other expenses. These stations are located on mountains commanding views for long distances, and are equipped with telephones and fire-fighting tools. Lookouts are maintained from June to November.

In Connecticut a firewarden system was provided by law in 1905. The state forester is ex officio forest firewarden without additional salary. About 400 wardens are under appointment, and the annual fire damage has been reduced to about one-fourth what it was before the adoption of the fire law.

In Wisconsin the state forester acts also as state firewarden, with power to appoint one or more firewardens in each town. Over 300 of these wardens are now under appointment in the northern part of the State. The State has also appointed an inspector, whose duty it is to examine all railroad locomotives in use in the northern part of the State, to see that they carry efficient spark arresters, and that the rights of way of the railroads are kept free from grass, brush, and other inflammable material.

Minnesota is one of the pioneers with regard to forest-fire protection. Supervisors of towns, mayors of cities, and presidents of village councils are ex officio firewardens under the direction of the chief firewarden, who is appointed by the forest commissioner. Five thousand dollars may be expended for fire fighting. Gen. C. C. Andrews, who as chief firewarden has been in charge of this work for many years, reports that the measures adopted have lessened the fire damage very greatly.

The Washington legislature enacted a forest-protection law in 1905. This law provides for the appointment by the governor of a state board of forest commissioners to serve without compensation. This board has power to appoint firewardens in each of the timbered counties of the State. While the measures taken have been effective in preventing fire damage to some extent, yet the number of wardens appointed (22 in 1905 and 23 in 1906) has been insufficient to meet to any degree the real needs of the situation. Outside the National Forests, fires have for the most part occurred on cut-over lands. This has given rise to an attempt to minimize the damage by fires which have occurred during the present season. In making estimates of such loss, however, little attention has been paid to the medium-sized material destroyed and none to the young growth. Almost invariably fires on cut-over lands encroach on virgin timber, and in the heavy forests of the Northwest the loss mounts up with great rapidity. Instead of spending $4,300, as in 1905, and $5,190, as in 1906, the State could well afford to appropriate such amount (between $25,000 and $100,000 annually) as would provide for an efficient patrol and make forest fires a thing of the past. As it is, the work of protection is, as a matter of fact, left to the individual owners to provide for.

In California the forest-fire situation is anything but satisfactory. One-third of the State, or approximately 33,000,000 acres, is in some degree forested, of which 25,000,000 acres are in the national forests. This leaves 8,000,000 acres of forest land for the protection of which the State is properly responsible, in addition to an immense area of chaparral, brush, and grass land, on which there is constant danger from fire during the dry season of the year. The only exception to this is perhaps in the redwood belt of Mendocino, Humboldt, and Del Norte counties, where, on account of the prevalence of summer fogs, fires do practically no damage over an extent of 1,000,000 acres. The greatest damage from fire is in the southern part of the State, along the foothill ranges, outside the National Forests. In the northern part much of the finest timber is in the hands of individuals and private corporations, and is situated outside the National Forests. But little protection from fire is furnished by lumbermen, and still less by the State. The annual loss from forest fires occurring outside the National Forests is upward of half a million dollars, according to the estimate of the state forester. There is great variation from year to year, the estimate for 1890 being upward of ten millions for the entire State, according to the report of the state board of forestry for 1889–90.

A voluntary firewarden system is in operation, appointments being made by the state forester. About 700 wardens have been appointed, who are given power under their appointments to arrest for violations of the forest laws, to issue burning permits (without which it is unlawful to set any except camp fires during a dry season), and to compel assistance in fighting fires. Because the State made no appropriation from which firewardens could be paid for their services, the preventive value of the system has not been great. To increase it, many counties have been requested to make appropriations, as allowed under the state law, from which firewardens acting within the county could be paid. This has resulted in the appropriation of money in the following counties to support the number of firewardens indicated:

Santa Cruz.—One firewarden.

Los Angeles.—One firewarden, and funds from which fire fighters are paid for their services.

San Bernardino.—Five hundred dollars from which firewardens are paid for their services.

Riverside.—Five hundred dollars from which firewardens are paid for their services.

Tulare.—Two hundred and fifty dollars for payment of firewardens.

San Diego.—Five hundred dollars for payment of firewardens.

Fresno.—Two regular firewardens and $500 for payment of services rendered by fire fighters.

Kern.—One thousand two hundred and fifty dollars for two regular firewardens and services rendered by fire fighters.

Merced.—One regular firewarden.

Glenn.—One regular firewarden.

Madera.—Two firewardens.

Santa Clara.—One firewarden.

In general, the best results from state efforts and the only ones which have been quite satisfactory have been derived from the action of several of the States in establishing state forests or parks. First in the list come New York, Pennsylvania, and Wisconsin; then the smaller beginnings made in Minnesota, Michigan, Connecticut, Massachusetts, New Jersey, Indiana, etc. The New York state forest preserve comprises 1,599,638 acres; the area of the Pennsylvania state reserve is 761,000 acres; and in Wisconsin 300,000 acres have been set aside as a state reserve, including 20,000 acres donated by the Federal Government. The area of lands reserved for forest purposes in some of the other States is as follows: Michigan, 39,000 acres; Minnesota, 42,800 acres; New Jersey, 9,867 acres; California, 3,800 acres; Indiana, 2,000 acres; Maryland, 1,957 acres; and Connecticut, 1,600 acres. Protection from fire is an important part of the system of management which it is expected will be inaugurated on these lands as rapidly as funds will permit. Judging from the example set by the most progressive states of continental Europe, the segregation, protection, and management of the state forests will ultimately become the principal line of state activity with regard to forest matters in this country. The conditions in Michigan are a good illustration of the desirability of such action on a large scale in States where there are cut-over forest lands not chiefly valuable for agriculture. Michigan owns at the present time about 800,000 acres, most of which has reverted to the State for nonpayment of taxes. These lands are in general not valuable for agricultural purposes.

They have cost the State millions of dollars in advertising and clerk hire; they have been sold over and over again at purely nominal prices without an investigation as to their value. The lands which the State now owns have been cut over repeatedly; immense areas come up every year for nonpayment of taxes; and still the State spends large sums trying to get rid of them. During the past five years Michigan has sold over 800,000 acres of tax lands at about $1.20 per acre. It is now shown by special examinations that they had timber enough on them to pay the above sum twice over. Thus the State has given away land and timber and young trees to the amount of millions of dollars. Not only that, but the lands thus sold are held by the owners just long enough to cut off the timber; the land then burns over, and the tract again reverts to the State for nonpayment of taxes. Thus the land policy pursued by this State has robbed the State of millions of money and of millions of acres, and directly resulted in the total and repeated devastation of immense areas of land chiefly valuable for the production of timber. Had the State kept its lands, sold them only on application and at fair price, and separated all poor lands as forest reserves, it would have received more money, these reserves would now produce an income instead of causing expense, fires would be done away with, and the State of Michigan would be in a fair way to supply itself again with all forms of timber instead of having to import them, as it now does. What is true of Michigan in this regard is true also of many other States. Where lands do not revert to the State for nonpayment of taxes, a policy of purchase, protection, and reforestation is the only practicable solution of the present unsatisfactory condition.

In addition to this policy, however, which can at the best be carried on but slowly, and which should include only lands not chiefly valuable for agriculture, the States should immediately take radical action to provide an efficient patrol for all forest regions. The many fires which have occurred during the present season in all parts of the United States emphasize this need with greater strength than has been the case in any previous year. In this connection the following quotation from The Minnesota Forester for September, 1908, is of interest as an illustration of conditions in the Northwest:

> On September 1, 1894, the forest fires swept over that portion of the State surrounding Hinckley. They wiped out that town completely, damaged several other towns, burned over 400 people, left over 2,000 others homeless, and destroyed property valued at $25,000,000. Investigations showed that the loss was the result of carelessness in regard to forest fires in their incipiency. It was shown that a reasonable amount of money expended by the State in patrol and other preventive measures would preclude any such disasters in the future.
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> Under pressure of public opinion and the findings in regard to the cause of the loss the legislature grudgingly appropriated $6,500 for forest protection, $1,500 to be paid to a chief forest firewarden. The legislature seemed to feel that it had met the requirements, but it had totally ignored the "reasonable amount."
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> Fourteen years later (1908) another fire wipes another town (Chisholm) off the map, damages others, leaves thousands of persons homeless, and destroys $5,000,000 worth of property. Investigation shows that the fire was caused by carelessness and neglect in fighting fire when it was small.
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> The direct and immediate loss from these two conflagrations was about $30,000,000. The consequent loss of wealth production in the following years would probably amount to more than that, but is ignored in these calculations, because few people look deep enough to see it. The direct losses, then, from these two fires would pay the state appropriation for fire protection, as it now stands, for the next 4,600 years. Is that not rather a low insurance rate,

especially when it is remembered that these two fires form only a fraction of the total losses to the State? The forestry commissioner has at his disposal about a quarter of a mill an acre for the protection of the land under his care. No business concern in the world would expect to get adequate protection at such ridiculously low rates.

An appropriation of half a cent an acre on the 20,000,000 acres of forest land would furnish efficient protection. That would mean an appropriation of $100,000 per year. It sounds like a great deal of money. The losses sustained in the Hinckley and Chisholm fires alone would pay it for 300 years. Considering that 20,000,000 acres are worth only $3 per acre—the value of all the towns in the district ought rightly to be figured in—we have a property worth $60,000,000. One hundred thousand dollars premium on even such a valuation would be less than 1½ mills on the dollar. What kind of insurance can be obtained for less?

It is to be hoped that the disasters in the neighborhood of Chisholm will awaken the state legislature to the ridiculous business methods which they have been using in the administration of their northern forests and impress upon them the necessity of larger appropriations to prevent such disasters in the future. The landowners in the forested districts pay taxes and should get protection; they get nothing else for their taxes and should insist on having the protection.

(3) RESULTS ACCOMPLISHED BY PRIVATE OWNERS.

In reply to questions sent out by the National Conservation Commission to owners of large tracts of forest lands throughout the United States, replies were received from 369 individuals or firms, representing holdings amounting to 13,150,085 acres. Of this area it was reported that 3,917,087 acres are protected from fire. This, however, does not mean that on this area the prevention of forest fires is secured, but that while prevention is secured in some cases, in general an organized attempt is made to extinguish such fires as may occur.

It is estimated that of the 450,000,000 acres of forest land in private ownership in the United States, probably not more than 1 per cent is under an efficient system of fire protection. By an efficient system is meant one in which prevention is the object sought rather than merely control after fires have actually begun. As already stated, for a system of this kind some plan of patrol is essential. A few years ago practically no attention was paid to forest fires by lumbermen and private owners, loss from this source being considered inevitable and pertaining naturally to the business. With the depletion of the timber supply, however, and the rapid rise in stumpage prices, a gradual change has taken place. Individual owners have been more ready to spend money to protect their holdings; cooperation has gradually developed in cases where fire danger is greatest, and in some instances, as in Idaho and in Washington, the movement for concerted action has spread until it has covered the largest timber interests of the respective States, involving even the State and Federal Governments in the general plan. The steps so far taken have been confessedly inadequate, since they have for the most part fallen far short of preventing fire damage. They are, however, moves in the right direction, and the results obtained show conclusively that fire damage can be practically eliminated provided the owners of forest property affected are willing to pay a reasonable amount for the protection. Money spent in this way is the cheapest possible form of insurance and is repaid many times over, not only in the form of the timber saved but in the higher values resulting from greater security from loss.

The Pocono Protective Fire Association is a good example of what can be accomplished in the way of preventing damage by forest fires through the cooperation of private owners. This association is an organization of forest owners in northeastern Pennsylvania, whose property aggregates upward of 100,000 acres. To stop the fires that have burned over their land every year the association began five years ago by securing the appointment of deputy constables in each of the seven townships in which its members own forest. Under the state law these men have all the powers of firewardens, including authority to call on any citizen to assist in fighting fire. A reward of $100 is offered for information leading to the arrest and conviction of any person starting a fire, or for such information as could be used as evidence against railroad companies. The expenses are met by an annual assessment of 6 mills per acre of land owned by the members. As a result strict enforcement of existing laws has been secured, and damage by forest fires has been practically eliminated on the tract in question.

The experiment conducted on the cut-over land of the McCloud River Lumber Company, in northern California, is a good example of what may be accomplished in the way of fire protection on forest lands in private ownership. This experiment was started in 1905, in accordance with a plan prepared by the Forest Service. The tract had been logged for the seven preceding years, and about 43,000 acres cut over. The amount of combustible débris left on the ground as a result of the lumbering operation was very great. Young growth existed in great quantities and of all sizes up to 18 inches in diameter. The problem was to adopt an adequate system of fire protection in order that the small and medium sized trees might reach merchantable size and at the same time the surrounding timber forest be protected from the menace incident to the proximity of so large an area of cut-over land. In accordance with the plan prescribed, fire lines were constructed at an average cost of $15 per mile. A patrol route was laid out, covered by a mounted patrolman daily for the four months of greatest fire danger—that is, from June to September. Tool stations were located at convenient points and telephone lines so constructed as to make it possible for the patrolmen to secure help quickly in case of fire. The total cost of protection for the area under patrol was 2 cents per acre, which included the initial cost for fire lines, tool stations, etc. As a result of the first year's work, the loss by fire was practically nothing, the few fires which really started having been speedily discovered by the patrolmen and extinguished without assistance.

In view of the success of the plan during the first year it was extended during 1906 to cover all the holdings of the company. These holdings are extensive and fairly well consolidated, and it will take a considerable time to cut over the present virgin stand. More important than this is the topographic character of the tract, which renders logging both easy and cheap. This, perhaps more than any other one thing, justifies the leaving of trees for a future cut, since the comparatively level nature of the country will make it possible to return again and log profitably, even where the stand per acre is relatively small. The cheapness of the protection secured on the McCloud tract and its thorough efficiency should serve as an object lesson to other owners of forest lands.

During the past year an efficient organization of lumbermen in northern Idaho has been formed, cooperating with the State, and known as the State and Lumbermen's Protective Association. The object is the prevention and control of forest fires on lands outside the national forests under private, corporative, and state ownership. Under the state law, wardens and deputies are appointed upon whom police powers are conferred. A paid patrol is maintained, and where necessary, temporary laborers are employed for fire fighting, the expense being apportioned among the respective owners and the State in proportion to the acreage of holdings involved. A complete system of trails has been outlined and work begun in many places. The patrolmen employed by the association are chosen on the basis of merit and their familiarity with the region in which they are to work. As a result of the adoption of the plan, a feeling of mutual interest has grown up between the State, lumber companies, individual owners of timber land, settlers, and all who are desirous of preventing and suppressing fires. There has also been cordial cooperation between the association and the Forest Service. Fires outside the national forests but near their boundaries were discovered by rangers of the Forest Service, who promptly notified the proper officials of the association. During this time the officers of the association were having their hands more than full with forest fires all over northern Idaho. In some instances the officers of the Protective Association were unable to handle the fires reported to them by the rangers, and in these cases the rangers, acting under the authority of the association, secured men and supplies and extinguished the fires, the expense of same being met by the association. In other instances the association put men and supplies at the disposal of the forest officers in fighting fires within the boundaries of the national forest.

On the Pacific coast the best example of cooperation among private owners is the Washington Fire Association, with headquarters at Seattle. This organization was effected early in 1908. It was incorporated under the laws of Washington "for the preservation of the forests of the State of Washington generally, and particularly from loss by forest fires, and the enlistment of the aid of the United States of America and the State of Washington in preserving said forests and preventing their destruction by fire."

The membership of the association includes 138 of the largest owners of timber lands in the Northwest, representing holdings aggregating 2,600,000 acres, 75 per cent of which is held by 8 or 10 companies. An assessment of 1 cent per acre for the season was levied. The amount thus secured was sufficient to carry the operations through the season, but had early rains not occurred, an additional levy of at least one-half cent per acre would have been necessary, as the fires were becoming larger and harder to handle. The timber companies were compelled to organize for protection, since the $7,500 appropriated by the legislature was sufficient only to maintain the office of the state firewarden and forester ~~and~~ to pay the salaries and expenses of the deputy firewardens in the different counties.

The administrative work of the association is conducted by the chief firewarden. During the season of 1908 the association had 75 men in the field from June 15 to September 15. These men were appointed forest rangers at large under the provisions of the state law, which gives authority to make arrests without warrant of persons violating the fire law. The State was divided into districts, each man covering approximately four townships. Seven inspectors were appointed, each one having charge of from 7 to 12 rangers. Weekly reports were required and suitable equipment furnished, consisting of ax, hoe, and water bag. In addition, tools, such as shovels, mattocks, saws, and buckets, were stored at convenient places. Most of the men were mounted on horses, some used wheels, and a few went on foot, owing to the country being too rough to permit the use of a horse. Every man was instructed to notify the deputy firewarden in the county and also the chief firewarden at Seattle by telephone or telegraph in case of a serious fire.

Most of the fires occurred during July and August, and the great majority were started from railroad locomotives and donkey engines. During these months the rangers extinguished 838 camp and other small fires covering not more than a few square rods; 162 small forest fires extinguished without any extra help or expense, generally not covering more than 5 acres; and 102 large fires, requiring extra help and expense; total, 1,102 fires. There were 18,773 acres of land burned over, of which 743 acres were timbered; of this it is estimated by the chief firewarden, Mr. D. P. Simons, jr., that one-half was damaged. There were employed 607 men, the total amount spent for fire fighting amounting to about $4,000, in addition to the salaries of the men under appointment. While excellent work was accomplished, considering the newness of the work and the number of men available, there is no question but that, as stated by Chief Firewarden Simons, twice the number of men actually employed should have been on duty.

In addition to the patrol and fire-fighting work, great good was accomplished by the forest rangers in inspecting logging locomotives and donkey engines and sawmills located in forest regions, and enforcing the law requiring efficient spark arresters. Companies operating logging locomotives, donkey engines, or mills not so equipped were allowed five days in which to comply with the law, and the request of the chief firewarden along this line was in every instance met by prompt compliance on the part of the company concerned.

It has been impossible to secure similar cooperation on the part of the railroads, according to Chief Firewarden Simons. The companies all claim to have a screen set diagonally in front of the tubes. This, however, is almost never kept in proper repair, owing to its serious interference with the steaming power of the locomotive. The coal used is of a poor grade and clogs the screens, so that the engineer usually opens the front and punches the screen full of holes. Mr. Simons believes that until a better grade of coal is used on the coast, or oil burners are adopted, there will always be trouble with forest fires caused by the railroads. An attempt was made by the association to induce the railroads to put on track patrolmen, but the only concession secured was the assurance that the section crews would assist in case of fires along the right of way.

Mr. Simons favors the appropriation by the State of $125,000 per year for fire protection. This would provide a sufficient field force to see that slashings are burned at the proper time, thus reducing the fire risk to a minimum. The cooperative establishment of telephone lines to reach inaccessible regions is another measure favored by the association which would aid greatly in securing proper fire protection.

In Wisconsin steps have been taken looking to the formation of associations for the prevention and control of forest fires similar to those in Idaho and Washington. The initiative has been taken by the state forester. The plan is to appoint patrols, to be employed during the dry season, the expense to be apportioned among the owners interested in proportion to the areas of their holdings. These patrols, when employed, would be appointed firewardens under authority of state law, and would receive every possible assistance and cooperation on the part of the state forester and other state officials.

In Connecticut the various water companies are especially active in fire prevention. Most of them have their superintendents appointed district firewardens. In the town of Simsbury the New York, New Haven and Hartford Railroad Company has cooperated with the authorities in establishing a fire patrol during April and May. The railroad company pays one-half of this expense, the town a portion, and the adjoining landowners the remainder. Some 40 fires were this year extinguished by this patrol, which would otherwise have burned over a large area that has been annually burned.

The Pennsylvania Railroad Company, operating in the eastern portion of the United States, has made some progress along the lines of fire protection. The problem is confined mainly to the prevention of fires on timber lands or wood lots owned or controlled by the company and along rights of way where injury to adjoining property might result in damage suits. On a watershed property of about 9,000 acres a firewarden has been employed during the spring and fall seasons for the past two years, who has patrolled the track and reported to the Altoona office any fires which he could not control. The results have been very satisfactory and no serious damages have occurred. In addition to the patrol, notices have been posted on several tracts calling attention to the danger from fire, and requesting the assistance and cooperation of all campers, berry pickers, etc. As a general measure of protection, and one which has proved very efficient, all employees in divisions which run through forested or brush lands are instructed at the beginning of the spring fire season to keep a look out for fires, extinguish those which they are able to reach and control, and report all others to division headquarters. These orders apply to trackmen, and as a result of the vigilance of a large number of men, fires have little opportunity to get beyond control before being reported. Probably the most dangerous region, from the standpoint of fires started from locomotive sparks, is in the southern part of New Jersey. Here, for many miles along the Cape May division and on the Newfield branch, a strip 100 feet wide on each side of the track is cut clean and burned over once or twice a year. On the outside of the strip furrows are plowed to prevent grass fires which start near the track from running into adjacent woodlands. The difficulty in this kind of protection is that the landowners frequently object to having such a strip cleared, and through the popular desire to hold up the railroads, the tendency is to charge a rental which makes such work prohibitive. Nevertheless, much good has been accomplished in the shape of fire prevention in this way.

In the South the best example of fire protection is the Pisgah forest, owned by the Vanderbilt estate, with headquarters at Biltmore, N. C.

This forest has an area of 130,000 acres, and has been under conservative forest management during the past twelve years. Protection against fire was the most serious problem which had to be met during the first years of management. The general policy has been to enforce strictly the fire and stock laws of the region, while at the same time cultivating in every possible way the friendship and good will of the native population and educating them to respect owners' rights and to see that the prevention of forest fires and of unrestricted grazing is for the best interests of the country as a whole. This policy has secured excellent results. Infractions of the fire and stock laws have been followed up vigorously as far as evidence could be obtained, as well as ordinary trespass, poaching, and theft of timber. The estate during the first few years experienced a great deal of trouble in these respects, with damage suits on hand much of the time. Within the last few years, however, trouble of this sort has greatly decreased. Moreover, the careful system of protection established on the tract has had a moral influence upon the native population. On the greater part the rangers claim that practically no spring fires are now started intentionally, and that there is very little trouble with the stock. The rangers keep on good terms with the natives as far as possible and show them the evil effects of fire and heavy grazing and the objects of the protective system on the estate.

This method has proved very successful, and as a result the local mountaineers have largely discontinued the practice of firing their own lands to improve grazing. Protection against fire is the principal duty of the head rangers. The ranges are marked out in regular sections across the tract, each including a portion of the high mountains on the Pisgah Range. On each range a number of elevated peaks have been selected from which practically the entire area can be clearly seen and fires readily detected. During any time of drought and fire danger these points are patrolled constantly, in some cases day and night, by assistant rangers, who are nearly always tenants on the tract. The main mountain patrol is usually made by men in pairs. When a fire is discovered one of these men hastens to it with all available help. The other hunts up and informs the head ranger and then collects a crew of fire fighters from the tenants on the range. The tenants, moreover, form a fire-fighting staff, loyal to the estate, equipped with saddle horses, and thoroughly acquainted with the region. They can be called upon at any time to fight the larger fires or to do special patrol work. A permanent staff of this kind makes the estate independent of outside help and avoids the danger of outsiders starting fires in the hope of securing employment. Between the tenants and the regular rangers, fires are usually quickly detected and extinguished. The roads and trails form a good network of fire lines, and are furthermore of the utmost value in protection, because they furnish rapid communication between all parts of the tract.

When a fire has not yet gained much headway, or is burning against the wind, or when the woods are comparatively moist and not burning readily, or the fire as usual in the fall is confined to the leaves, the men form a line and beat it out directly with hemlock boughs, sacks, or bunches of hard-wood twigs.

When the fire is well under way, especially if the woods are dry and burning fiercely, with a good deal of combustible material on the ground, or if the fire is running with the wind, the men begin at once to back fire. They usually work in crews of eight. Two men go ahead with pitchforks, clearing a strip about 5 feet wide of combustible material. Two others follow with rakes, completing the clearing of the strip by raking off the leaves and smaller twigs. Care is taken to direct the line well away from down timber or logs and dead stubs or stumps which might enable the back fire to jump the trail. Two more men follow, firing the leaves on the side of the strip toward the blaze, the rest of the crew spreading out along the strip at close intervals to see that the fire does not jump the cleared path. The lane and back fire can in this way be run very rapidly, often at the rate of a mile or a mile and a half an hour.

The system of protection used on this tract, while expensive, appears to be very effective. The aim is to keep out fire at any cost. No risk is taken that can be avoided at reasonable expense, under the general plan of spending money to keep out fire rather than in fighting fire after it once gets in. In this way thoroughgoing protection has been secured, though at an annual cost of probably 4 cents an acre.

CONCLUSION.

The direct loss to the United States each year from forest fires is not less than $50,000,000. The indirect losses are beyond calculation, but are certainly several times as great as the direct loss. Experience both in Europe and the United States shows conclusively that loss from forest fires is practically preventable at reasonable expense. Except on the National Forests and in a few isolated instances the measures adopted are totally inadequate to meet the needs of the situation. What is needed is a general realization by the public of these facts, followed by the improvement and enforcement of existing laws and the expenditures of adequate sums of money as a business measure, not only by the Federal Government but by the States and by corporations and private owners of forest lands. Further delay is business folly as well as a national calamity.

WASTE AND REDUCTION OF TIMBER SUPPLIES CAUSED BY INSECTS, AND METHODS OF PREVENTION AND CONTROL.

By A. D. Hopkins,
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CHARACTER AND EXTENT OF DEPREDATION.

The records of notable depredations by insects on the timber supply of Europe during the past four hundred years, and on that of the United States during the past century, and especially those that have come under the observation of the writer and his assistants during the past eighteen years, furnish conclusive evidence that this class of enemies has been, and is now, an important factor in the destruction and waste of forest resources.

CAUSE OF THE DEATH OF TIMBER.

It has been determined that in this country certain species of insects are the direct or primary cause of the death of trees of all ages, and that from time to time they multiply to such an extent as to take the character of a destructive invasion, resulting in the death of a large proportion of the timber of certain species over many square miles.

Examples.

The southern pine beetle.—A destructive invasion by the southern pine beetle (*Dendroctonus frontalis* Zimm.) in 1890–1892 extended from the western border of West Virginia through Maryland and Virginia into the District of Columbia, northward into southern Pennsylvania, and southward into North Carolina. In this area, aggregating over 75,000 square miles, a large percentage of the mature and small trees of the various species of pine and spruce was killed by this beetle. In certain localities in West Virginia and Virginia nearly all the pine trees of all sizes were killed on thousands of

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[Note.—The statements and estimates in this report are based largely on observations and the results of investigations by the writer and his assistants, and information secured through correspondence with forest officials and private owners of timber and manufacturing enterprises. Much of it has been published in the various bulletins and circulars of the Bureau of Entomology, the West Virginia Agricultural Experiment Stations, and in proceedings of societies, etc., but there is also much original matter drawn from the unpublished notes and records of the Branch of Forest Insect Investigations of the Bureau and from the unrecorded experience and observations of the writer. Some of the statements and estimates may seem to be overdrawn or exaggerated, but they are based on available evidences and facts which indicate to the writer that they are conservative.—A. D. Hopkins.]

acres, while shade and ornamental trees within the same area suffered the same as those in the forest. It has been more or less active in the States south of Virginia to Texas since 1902, and in some localities and during some years it has killed a large amount of timber. Records of extensive dying of timber in the Southern States are found dating back to the early part of the nineteenth century. Therefore, this species may be considered as one of the most dangerous enemies and a constant menace to the pine forests of the Southern States.

The eastern spruce beetle.—During the period between 1818 and 1900 there were a number of outbreaks of the eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) in the spruce forests of New England and southeastern Canada. It caused the death of a large percentage of the matured spruce over many square miles. The larger areas of this dead timber evidently furnished fuel for devastating forest fires, with the result that in most cases there was a total loss.

The Engelmann spruce beetle.—Another bark beetle of the same genus, and with similar habits, has from time to time during the past fifty years caused widespread devastations in the forests of Engelmann spruce of the Rocky Mountain region, in some sections killing as high as 90 per cent of the merchantable sized timber.

The Black Hills beetle.—One of the most striking examples of the destructive powers of an insect enemy of forest trees is found in the Black Hills National Forest of South Dakota, where during the past ten years a large percentage of the merchantable timber of the entire forest has been killed by the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.). It is estimated that a considerable part of the total stand of timber has died in this forest as the direct result of the work of this beetle. This destructive enemy of the western yellow pine is distributed through the forests of the middle and southern Rocky Mountain region, in which it has been found that within recent years a large amount of timber has been killed by it, not scatteringly through the forests of the entire region, but here and there areas of greater or less extent where from 10 to 80 per cent of the trees have been killed by it.

The mountain pine beetle and western pine beetle.—The sugar pine, silver pine, western yellow pine, and the lodgepole pine of the region north of Colorado and Utah, westward to the Cascades and southward through the Sierra Nevada, are attacked by the mountain pine beetle (*Dendroctonus monticolæ* Hopk.) and the western pine beetle (*Dendroctonus brevicomis* Lec.), and, as a direct consequence, billions of feet of timber have died. In one locality investigated in northeastern Oregon it is estimated that 90 to 95 per cent of the timber in a dense stand of lodgepole pine, covering an area of 100,000 acres, has been killed within the past three years by the mountain pine beetle. Throughout the sugar-pine districts of Oregon and California a considerable percentage of the largest and best trees are dead as the result of attacks by this same destructive bark beetle.

The Douglas fir beetle.—The Douglas fir throughout the Rocky Mountain region from southern New Mexico to British Columbia has suffered severely from the ravages of the Douglas fir beetle (*Dendroctonus pseudotsugæ* Hopk.) resulting in a large percentage of dead timber, much of which will be a total loss.

Three other species of beetles of destructive habits, similar to those mentioned, depredate on the pines of New Mexico and Arizona, and still another has contributed greatly to the destruction of the eastern larch throughout the northeastern United States and southeastern Canada.

The hickory barkbeetle.—Within the past ten years the hickory barkbeetle (*Scolytus quadrispinosus* Say) has been the cause of the death of an enormous amount of hickory timber throughout the northern tier of States from Wisconsin to Vermont and southward through the eastern Atlantic States and into the Southern States as far as central Georgia.

The larch worm.—There are many examples of widespread depredations by insects which defoliate the trees and thus contribute to their destruction. Notably among these is the larch worm (*Nematus erichsonii* Hartig), which, during a number of extensive outbreaks since 1880, has killed from 50 to 100 per cent of the matured larch over vast areas in the northeastern United States and southeastern Canada. It is believed that the amount of merchantable sized timber that has died as a result of defoliation by this insect will aggregate many billions of feet.

INJURIES TO THE WOOD OF LIVING TREES.

It has been determined that a certain class of insects attack the wood and bark of living timber and that while they do not contribute materially to the death of the trees or show much external evidence of their presence, they cause wounds in the bark and wormhole and pinhole defects in the wood that often result in reductions in value amounting to from 5 to 50 per cent. The defects in the wood are not detected until after the trees are felled and the logs are transported to the mill and converted into lumber. Thus to the actual damage to the wood is added the expense of logging and manufacture of the defective low-grade material, much of which is discarded as worthless culls.

EXAMPLES.

The oak timber worm.—One of the most destructive of this class of depredators is the oak timber worm (*Eupsalis minuta*). It enters the trunks of living trees through wounds in the bark and at the base of broken or dead branches and extends its "pinhole" burrows in all directions through the solid heartwood. The losses occasioned by this insect in the hard-wood forests of the eastern United States are enormous and usually affect the finest examples of old trees.

The chestnut timber worm.—The chestnut throughout its range is damaged in a like manner by the chestnut timber worm (*Lymexylon sericeum*). Practically every tree of merchantable size is more or less affected and a large percentage are so seriously damaged that the product is reduced to the lowest grade. It is estimated that reduction in value of the average lumber product at any given time is not far from 30 per cent, thus involving extensive waste and an increased drain on the forest to supply the requirements for clear lumber. This insect also attacks the oaks, and especially the red oak, the older trees of which are often as seriously damaged as the chestnut.

The carpenter worm.—The oaks, especially the white oak and red oak, are seriously damaged by carpenter worms of the genus *Prionoxystus*. The holes made by them through the heartwood of the best part of the trunks are sometimes one and one-half inches in diameter one way by three-fourths of an inch the other, thus causing serious damage to the wood. These, with other large wood-boring grubs of beetles, sometimes infest the top part of the trunk and larger branches where their continued work results, first, in the dead and so-called "stag-horn" top and, subsequently, in broken, decayed, and worthless trunks.

The columbian timber beetle.—One of the most common defects in white oak, rock oak, beech, whitewood or yellow poplar, elm, etc., is that known to the lumber trade as "grease spots," "patch worm," and black holes. This is caused by one of the timber beetles or ambrosia beetles (*Corthylus columbianus* Hopk.) which makes successive attacks in the living healthy sapwood from the time the trees are 20 or 30 years old until they reach the maximum age. Thus the black hole and stained wood defect is scattered all through the wood of the best part of the trunks of the trees. The average reduction in value of otherwise best grade of timber in many localities amounts to from 25 to 75 per cent. The defect is commonly found in oak and elm furniture and in interior hard-wood finish in dwellings and other buildings.

The locust borer.—The locust, as is well known, suffers to such an extent from the ravages of the locust borer (*Cyllene robiniae*) that in many localities the trees are rendered worthless for commercial purposes or are reduced in value below the point of profitable growth as a forest tree; otherwise this would be one of the most profitable trees in the natural forest or artificial plantation and would contribute greatly to an increased timber supply.

The turpentine beetle and turpentine borer.—While the soft wood or coniferous trees suffer far less than the hard woods from the class of enemies which cause defects in the living timber, there are a few notable examples of serious damage. There is a common trouble affecting the various species of pine throughout the country known as basal wounds or basal fire wounds. It has been found that a large percentage of this injury to the pine in the States north and west of the Gulf and the Middle and South Atlantic States is caused by the dark red turpentine beetle (*Dendroctonus valens* Lec.), and in the Southern States by the black turpentine beetle (*Dendroctonus terebrans* Oliv.). These beetles attack the healthy living bark at and toward the base of the trunks of medium to large-sized trees and kill areas varying from 1 to 10 square feet. This is subsequently burned off by surface fires and is then generally referred to as fire wounds. The further damage to the exposed wood by successive fires, decay, and secondary insects often results in a total loss of the best part of the tree, or a reduction in values of from 10 to 50 per cent of the lower section of the trunk. These and similar wounds in the bark of trees, including those caused by lightning and by the exposure of the wood in turpentining, offer favorable conditions for the attack of the turpentine borer (*Buprestis apricans*). The work of this insect and two or three others with similar habits is very extensive and causes losses amounting to 10 to 50 per cent of the wood of the best part of the trees thus affected.

The white pine weevil.—The abnormal development of white pine trees as the result of successive attacks on the terminals of saplings and young trees by the white pine weevil (*Pissodes strobi* Peck) is an element of loss of considerable importance, especially in mixed stands and in open pure stands of this timber. The value of such trees is reduced 20 to 50 per cent, and there is an additional loss from the effect of their spreading branches or crowns in the suppression or crowding out of trees which would otherwise occupy the space thus usurped.

There are many other examples of damage by insects to the wood and bark of living trees, but those mentioned should be sufficient to demonstrate the importance of insects in their relation to injuries to the wood and growth of living timber.

INJURY TO THE WOOD OF DYING, AND DEAD TREES.

Timber dying and killed by insects and other causes, including fire, disease, storm, etc., is attacked by a class of wood-boring insects which extend their burrows through the sound sapwood and heartwood and thus contribute to the rapid deterioration and decay of a class of resource which otherwise would be available for utilization during periods of from one to twenty years or more after the death of the trees, depending on the species of trees and character of product desired. This loss often amounts to from 25 to 100 per cent during the period in which the dead timber would otherwise be almost as valuable as living timber.

EXAMPLES.

CONIFERS.

Sawyers.—One of the striking examples of the destruction or deterioration of dying and dead timber familiar to all lumbermen is the injury to fire-killed and storm-felled white pine caused by boring grubs known as sawyers. Pine, fir, spruce, etc., are affected. These borers hatch from eggs deposited by the adult beetles in the bark of the dying trees, and after feeding on the inner bark for a time they enter the solid wood and extend their large burrows deep into the heartwood. Fire-killed white pine is especially liable to this injury, and is often so seriously damaged within three or four months during the warm season as to reduce materially the value of the attacked timber. The shortleaf, loblolly, and longleaf pine of the Southern States are damaged to a somewhat less extent, but examples are known of storm-felled timber within limited areas being reduced in value 25 to 35 per cent within three months after the storm. The fire and insect killed sugar pine, silver pine, and yellow pine of the western forests are also damaged in a similar manner, and the value of the product greatly reduced within a few months after the trees die. The losses from this secondary source in the coniferous forests contribute greatly to the annual waste of millions of dollars' worth of forest products.

Ambrosia beetles.—There is another class of wood-boring insects known as "timber beetles" or "ambrosia beetles," which cause pinhole defects principally in the sapwood, but some of them extend their burrows into the heartwood. These insects make their attack in the early stage of the declining or dying tree or before the sapwood has materially changed from the normal healthy condition, and often in such numbers as to perforate every square inch of wood.

The wood is thus not only rendered defective from the presence of pinholes, but the holes give entrance to a wood-staining fungus, which causes a rapid discoloration and still further deterioration of the product.

The value of the sapwood of trees dying from insect attack, fire, storm, and other causes is often reduced 50 per cent or more, and in some cases the value of the heartwood is reduced in a like manner 5 to 10 per cent.

Pin hole borers in cypress.—Another example of the destructive work of this class of insects is found in the cypress timber in the Gulf States, where the trees are deadened by the lumbermen and left standing several months or until it is dead and sufficiently dry to float. Upon investigation it was found that trees deadened at certain seasons of the year were attacked by the ambrosia beetles, and that in some cases the value of millions of feet of timber had thus been reduced 10 to 25 per cent or more.

HARDWOODS.

Roundheaded timber worms and ambrosia beetles.—The principal damage to dying and dead hardwood trees is caused by certain roundheaded (Cerambycid) wood borers, with habits similar to the sawyer, and by the timber worms mentioned as damaging living timber; also by ambrosia beetles, with habits similar to those that attack the sapwood and heartwood of conifers. All of the hardwoods suffer more or less, but the greatest damage is done to the wood of hickory, ash, oak, and chestnut, which are often reduced in value 10 to 25 per cent or more within the period in which the wood would otherwise be sound and available for utilization.

INJURY TO FOREST PRODUCTS.

During the process of utilizing forest resources, from the time the trees are felled until the logs are converted into the crude and finished product, and until the latter reaches the consumer, or even after it is placed in the finished article or structure, damage is caused by various species of insects which are attracted by the varying conditions prevailing at different stages in the process. As a result, additional drains are made on the timber to meet the demand for the higher grades of lumber and other supplies to replace that which has been injured or destroyed. From the writer's personal investigations of this subject in different sections of the country, the damage to forest products of various kinds from this cause seems to be far more extensive than is generally recognized. This loss differs from that resulting from insect damage to natural forest resources in that it represents more directly a loss of money invested in material and labor.

EXAMPLES.

Crude Products.

Roundheaded borers, timber worms, and ambrosia beetles.—Round timber with the bark on, such as saw logs, poles, posts, mine props, etc., are subject to serious damage by the same class of insects as those mentioned under character of injury to dying and dead trees.

The damage is especially severe when material is handled in such a manner as to offer favorable conditions for attack, such as leaving the logs in the woods on skidways or in mill yards for a month or more after they have been cut, when under such conditions there is often a reduction in value of from 5 to 30 per cent or more, due to wormhole and pinhole defects caused by roundheaded and flatheaded wood borers and timber beetles. Frequently the insects continue the work in the unseasoned and even dry lumber cut from logs which had been previously infested. They also continue to work in mine props after they have been placed in the mine, and in logs and other material used for the construction of cabins, rustic houses, etc., and in round timbers generally.

The products from saplings, such as hickory hoop poles and like material, are often seriously injured or rendered worthless by roundheaded and flat-headed borers and wood-boring beetles, sometimes resulting in a great loss of the merchantable product.

Stave and shingle bolts left in moist, shady places in the woods or in close piles during the summer months are often attacked by ambrosia beetles and timber beetles. The value of the product is, in consequence, often reduced 10 to 50 per cent or more.

Handle and wagon stock in the rough is especially liable to injury by ambrosia beetles and roundheaded borers. Hickory and ash with the bark on are almost certain to be greatly damaged if the logs and bolts cut from living trees during the winter and spring are held over a few weeks after the middle of March or first of April.

Pulp wood, and cord wood for fuel and other purposes, cut during the winter and spring and left in the woods for a few weeks or months, or in close piles after the beginning of the warm weather, are sometimes riddled with wormholes or converted into sawdust borings, causing a loss of from 10 to 100 per cent. One example reported from near Munising, Mich., represents a loss of $5,000 from injury to spruce and fir pulp wood cut in the winter and kept in piles over summer.

MANUFACTURED UNSEASONED PRODUCTS.

Ambrosia beetles and other wood borers.—Freshly sawed hardwood placed in close piles during warm, damp weather during the period from June to September is often seriously injured by ambrosia beetles. Heavy two to three inch stuff is also liable to attack by the same insects, even in loose piles. An example of this was found in some thousands of feet of mahogany lumber of the highest grade which had been sawed from imported round logs and piled with lumber sticks between each tier of plank where native species of ambrosia beetles, principally *Pterocyclon mali* Fitch, had entered the wood to such an extent as to have reduced the value 50 per cent or more within a few weeks. Oak, poplar, gum, and other similar woods often suffer severely from this class of injury, causing losses varying from 5 to 50 per cent.

Lumber and square timbers of both soft and hard woods with the bark left on the edges are frequently damaged by flat-headed and roundheaded wood borers which hatch from eggs deposited in the bark before or after the lumber is sawed. There are examples of losses from this character of injury amounting to 20 to 50 per cent or more.

Telegraph and telephone poles, posts, mine props, etc., are frequently injured before they are set in the ground, especially if the bark remains on them during a few weeks after the middle of March.

SEASONED PRODUCTS IN YARDS AND STOREHOUSES.

Powder post beetles.—Hardwood lumber of all kinds, rough handle and wagon stock, etc., partially or entirely of sapwood, are often reduced in value 10 to 90 per cent by a class of insects known as "powder post beetles." The sapwood of hickory, ash, and oak is most liable to attack. The reported losses from this source during the past five or six years indicate that there has been an average reduction in values of from 5 to 10 per cent or more.

Old hemlock and oak tan bark are often badly damaged by various insects which infest dead and dry bark that in some tanyards as much as 50 to 75 per cent of the bark that is over three years old is destroyed. In one tannery in West Virginia it is estimated that more than $30,000 worth of hemlock bark was thus destroyed.

FINISHED AND UTILIZED PRODUCTS.

FINISHED PRODUCTS.

Powder post beetles.—It is in the finished hardwood products, such as handles, wagon, carriage, and machinery stock, that the greatest damage and loss is occasioned by powder post beetles. This is especially true of hickory and ash handles and like products in storehouses, including the vast amount of material held in storage for the army and navy. When material of this kind is once attacked it is usually worthless for the purposes indicated, and therefore must be replaced with new material. In some cases losses have amounted to from 10 to 50 per cent, and it is estimated that the average losses have been as much as 10 per cent on all sapwood material that has been in storage more than one year.

UTILIZED PRODUCTS.

Powder post beetles and other wood borers.—The finished woodwork in implements, machinery, wagons, furniture, and inside finish in private and public buildings is often seriously damaged by powder post beetles.

Construction timbers and other woodwork in new and old buildings are often so seriously damaged by powder post beetles, white ants, and other wood-boring insects that the affected material has to be removed and replaced by new or the entire structure torn down and rebuilt.

Construction timbers in bridges and like structures, railroad ties, telephone and telegraph poles, mine props, fence posts, etc., are sometimes seriously injured by wood-boring grubs, termites, black ants, carpenter bees, and powder post beetles, and sometimes reduced in efficiency from 10 to 100 per cent.

INSECTS IN THEIR RELATION TO THE REDUCTION OF FUTURE SUPPLIES.

Insects not only reduce future supplies by killing the matured trees and destroying timber that is inaccessible for utilization, but through injuries during the flowering, fruiting, germinating, seedling, and sapling periods of early growth, prevent normal reproduction and development.

INTERRELATION OF INSECTS AND FIRE.

DURABILITY OF INSECT-KILLED TIMBER.

Timber killed by insects and fire would be available for utilization for many years were it not for injuries through secondary attacks of wood-boring insects and the destruction of insect-killed timber by forest fires. Some of the matured larch trees, evidently killed by the larch worm between 1881 and 1885, that had escaped subsequent depredations by fire and wood-boring insects, are now (1908) standing, and sound enough to be utiilzed for railroad ties and many other purposes. The heartwood of red spruce and Engelmann spruce, Douglas fir, white pine, etc., has been found by the writer to be sound enough for profitable utilization for pulp wood, lumber, fuel, etc., twenty to thirty years after it had been killed by insects or fire.

INSECT-KILLED TIMBER DESTROYED BY FIRE.

It has often happened that after insects had killed the timber over extensive areas forest fires followed and destroyed the dead timber. Indeed, abundant evidence has been found during recent investigations to prove that some of the denuded areas in the Rocky Mountain and other sections of the country are primarily due to devastations by insects, and that subsequent fires destroyed the timber and prevented reproduction.

FIRE-KILLED TIMBER INJURED BY INSECTS.

On the other hand, there is a vast amount of timber which has been killed outright or has died as the direct result of forest fires, but in every observed case insects have contributed more or less to the death of fire-scorched trees, which otherwise might have recovered, and especially to the rapid deterioration of a large per cent of the injured and killed trees. It is evident that in some cases fire-scorched and fire-killed timber has contributed to the multiplication of one or more of the destructive enemies to the living timber, and thus the injury started by the fire may have resulted in a destructive invasion of beetles. However, it is evident that this has happened only when the destructive beetle was already present in abnormal numbers in the forest surrounding the fire-swept area. Therefore, it is believed that injuries by fire are not as a rule an important factor in contributing to subsequent depredations by bark beetles. Such fires do, however, contribute to the multiplication of the insects which depredate on the wood, so that in forested areas where fires are frequent the damage to dying and dead trees is more severe, and fewer injured trees recover on account of the abundance of secondary bark-beetle enemies which do not, as a rule, attack living timber.

DESTRUCTION OF INSECTS BY FIRE.

There is another important feature in the relation of insects and fire, in which the fire contributes to the destruction of the principal bark-beetle enemies of the living timber. This happens when the fire burns the timber while it is infested, and thus effectually destroys the broods of the insects before they emerge. It is perfectly plain that the dying and dead foliage of the beetle-infested trees and the dead bark on the trunks would contribute to the starting and spread of crown fires, and thus the bark on the entire infested trunks would be sufficiently scorched to kill the insects. Therefore complete fire control may easily contribute to more extended depredations by insects on the living timber.

INTERRELATION OF FOREST INSECTS AND FOREST FUNGI.

DECAY FOLLOWS INJURY BY INSECTS.

It is well known that the burrows in the bark and wood of living and dead trees and in the crude and finished products often contribute to the entrance of bark and wood decaying fungi. Deterioration and decay are thus far more rapid than would otherwise be possible. It is also known that trees injured and dying from evident primary attack of parasitic fungi are attractive to certain insects which breed in the bark and wood of sickly and dying trees, and that certain other complicated troubles affecting forest trees are the result of an intimate interrelation and interdependence of insects and fungi. There can be no doubt, however, that certain species and classes of both insects and fungi are independently capable of attacking and killing perfectly vigorous and healthy trees.

BARK BEETLES KILL TREES IN AMERICA.

While there has been some question in European and other literature as to whether bark beetles ever attack healthy timber and kill it, the extended investigations by experts in this country, including detailed studies and experiments, have resulted in the accumulation of abundant evidence to prove conclusively that there are many species of bark beetles and other insects which not only attack perfectly healthy trees, but that they do so through preference and necessity. Furthermore, that they are not only capable of causing serious injury to trees during growth but they have killed century-old trees, and therefore are capable of killing a very large per cent of all of the pines, spruces, or larch within the area of their normal distribution.

SUMMARY OF CHARACTER AND EXTENT OF WASTE CAUSED BY INSECTS.

The killing of trees by insects; the damage to living timber and to crude and finished products by insects; the damage by fire following attack by insects after fire; and the damage from decay as the result of insect injury to trees previously injured and killed by both insects and fire, have been, and are now, continuing throughout the forested areas of the country, including private parks and the farmers' woodlots. Though not always evident in some forests or sections, yet every year, or series of years, there are conspicuous and widespread depredations somewhere in the forests of the country. In every forest and woodlot there is an ever-present but inconspicuous army of insects which requires for food and breeding places the bark, wood, foliage, and seeds of the various commercial tree species. The damage wrought in a single locality by these general enemies of the forests may not be noticed in a single year, but the accumulated injuries wrought during the period required for the growth of a tree from a seedling to commercial size goes far toward reducing the annual average increment below the point of profitable interest on private and public holdings.

The accumulated damage to crude, finished, and utilized products reduces the profits of the manufacturer, increases the price of the higher grades to the consumer, and results in an increased drain on the natural resources.

ESTIMATES.

In any attempt to estimate the extent of losses or waste of timber supplies to be expressed in dollars or feet, there are many conflicting factors which prevent reliable conclusions, in addition to the fact that we have no accurate information as to the actual amount in board feet of standing timber in the country and consequently no accurate data or average cash values. The same holds good, but to a less degree perhaps, with regard to percentages of damaged and destroyed supplies to that unaffected by insects. Therefore, until more complete data can be furnished by experts on forest statistics, any predictions must be based on estimated statistics and the facts and evidences observed by the writer and his field assistants, correspondents, etc., relating to the principal forest areas of the entire country, which are believed by the writer to be conservative, and he is confident that accurate statistics of the existing conditions in the country at this time would fully support it.

REDUCTIONS IN THE NATION'S WEALTH.

If the resources in merchantable timber and forest covers are considered as an element of the nation's wealth, as an asset of a given value to the people for direct utilization, protection to the land from erosion, protection of headwater streams and of game, and as contributing to the attractiveness of health and pleasure resorts, it would be difficult indeed to estimate the amount or per cent of losses or the reduction in values chargeable to insects. It is plain, however, that in the aggregate it would amount to an enormous sum.

REDUCTION IN VALUE OF COMMERCIAL AND FINISHED PRODUCTS.

If we consider the aggregate loss to the trade and to manufacturers and consumers of finished products caused by insects, it is evident that it would amount to many millions of dollars annually, in addition to increased drain on the forest to replace woods prematurely destroyed by insects.

METHODS OF PREVENTION AND CONTROL.

POSSIBILITIES OF CONTROL.

The results of extensive investigations and of practical applications during recent years have demonstrated that some of the most destructive insect enemies of American forests and of the manufactured and utilized products can be controlled, and serious damage prevented, with little or no ultimate cost over that involved in forest management and business methods.

There are, of course, certain insects and certain injuries which under present conditions and available information can not be controlled or prevented, but it is very evident that if the information now available through the publications of the Department of Agriculture and through direct correspondence with its experts be properly utilized in the future, it will result in the prevention of at least 30 per cent of the estimated annual waste of forest resources caused by insects.

GENERAL METHODS OF CONTROL.

The ordinary spraying and similar methods of dealing with fruit and shade tree insects are, of course, not available for practical application in the case of forest trees.

In all efforts to control an outbreak or prevent excessive losses, it should be remembered that as a rule it is useless to attempt the complete extermination of a given insect enemy of a forest tree or forest product. Experience has demonstrated that it is only necessary to reduce and weaken its forces at least 75 per cent, so that it can not continue an aggressive attack, but must occupy a defensive position against its own enemies and become dependent upon favorable conditions resulting from avoidable negligence and mismanagement by the owners of the forests and manufacturers of forest products, thus can be easily kept under control by good management.

The desired control or prevention of losses can often be brought about by the adoption or adjustment of the requisite details in forest management and in lumbering and manufacturing operations, storing, transporting, and utilizing the products, which at the least expenditure will cause the necessary reduction of the injurious insects and establish unfavorable conditions for their future multiplication or continuance of destructive work.

It is, however, of the utmost importance that any adjustment or modification in management or business methods should be based on expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved and on knowledge of the essential features of methods of control. This should be supplemented by expert knowledge or advice on the principles of technical and applied forestry in the proper management, care and utilization of the forests and its resources, and still further supplemented by practical knowledge and experience relating to local conditions and facilities.

As has been shown, the matured or merchantable-sized timber is most liable to injury or death from the ravages of insects. Therefore, considered from the standpoint of insect control and the prevention of one of the greatest items of loss, it is important that such timber should be utilized before it begins to deteriorate, or before it reaches the stage of unprofitable growth.

In order to be most successful in dealing with forest insects it must be recognized that each species differs to a greater or less extent from all other species, even of the same genus; that there are also certain characteristics of the different tree species which differ from those of all other tree species; and that as a rule it is the technical knowledge of these peculiar features or characteristics of the trees and their enemies which furnishes the clue to successful methods of control.

There are also many peculiar features in prevailing conditions in different localities, some of them favorable, others unfavorable, for the practical application according to a given method, so that while certain general advice may apply in a broad sense, it is often necessary to diagnose a given case before specific expert advice can be given as to the exact cause and the most effective method to be adopted, just as a physician must diagnose a case of illness or injury before prescribing the necessary treatment for his patient.

Therefore, in answering the question of the commission as to how far the waste of forest resources caused by insects can be prevented and how far the damaged timber can be utilized, we will attempt to give only general statements, based on the results of our observations, relating to some of the principal character of losses discussed in the first part of this report, namely, insects which (1) kill the trees, (2) cause injuries to the wood of living timber, (3) reduce future supplies, (4) cause injuries to the products; (5) the utilization of natural enemies of injurious insects, (6) the utilization of damaged timber, and (7) present conditions and opportunities.

CONTROL OF BARK BEETLES WHICH KILL TREES.

The bark beetles which kill trees attack the bark on the main trunk and destroy the life of the tree by extending their burrows or galleries in all directions through the inner living bark. The broods of young grubs or larvæ develop within the inner bark, on which they feed. Those of some species develop to the adult stage within the inner bark and are exposed when the bark is removed, while those of other species transform to the adults in the outer corky bark and the larvæ are not exposed when the bark is removed. Some species have two or more seasonal or annual generations, while others have but one, and in a few species it requires two years for a single generation to develop.

The bark beetles of the genus *Dendroctonus* represent the most destructive enemies of the principal coniferous American forests, and at the same time are among the easiest to control. The general requisites for success are embodied in the following rules:

(*a*) Give prompt attention to the first evidence of a destructive outbreak, as indicated by an abnormal per cent of yellow or red topped dying trees, and especially when such trees occur in groups of 10 or more or cover large areas; (*b*) secure authentic determination of the particular species of insect responsible for the trouble; and (*c*) take prompt action toward their control according to specific expert advice on the best method for the destruction of the necessary 75 per cent or more of the insects in the infested trees.

Some of the methods to be adopted to meet the requirements of various local conditions are as follows:

1. Utilize the infested timber and burn the slabs during the period in which the broods of the destructive beetles are in the immature stages or before the developed broods emerge from the bark; or
2. Fell the infested trees and remove the bark from the main trunk and burn the bark, if necessary;[a] or
3. Remove the infested bark from the standing timber and burn the bark, when necessary;[a] or
4. Immerse the unbarked logs in ponds, lakes, or streams, where the bark will remain soaked long enough to kill the insects; or
5. Remove the unbarked logs or products to a locality where there are no trees liable to attack within a radius of 20 miles or more.

TO MAINTAIN CONTROL OF BARK BEETLES.

Future trouble of a serious nature from this class of insects can be prevented if an insect-control policy is adopted in connection with, or independent of, a fire-control policy by which groups of dying trees will receive the same prompt attention as that given to forest fires.

Applications in state and national forests.—In all forest reserves in which there is an organized force of rangers and firewardens or opatrols, each officer should be furnished with instructions as to the location of beetle-infested trees, and with equipments and directions for taking the necessary action whenever the conditions demand it.

Private forests.—Private forests should receive the same attention as public forests, but it is often far more difficult on account of intervening forests, where the owners either can not or will not give the matter the required attention. While it may be advisable to have some laws to govern the treatment of timber infested with a dangerous pest when the owner refuses to take any action, such laws should apply only to the more extreme cases or as a last resort on authoritative advice. It is probable that in most cases legislation will not be necessary, and more ultimate good will result without than with strict laws, especially when it can be made clear to the owner that his personal interests demand that he take the proper action and that, when necessary, his neighbors will render assistance, as is often done in the case of a forest fire.

Inaccessible areas.—There are yet large, inaccessible areas in the East and West where it is not practicable or possible at present to attempt to control the depredations by these beetles, and therefore they must be left to the natural adjustment that has been going on in all primitive forests from the beginning. While under such natural control much of the older matured timber will be lost, it will usually be replaced by young growth, either of the same or of different species, so that under normal conditions the forest will be perpetuated, but under exceptional conditions and combinations of detrimental influences, such as secondary insect enemies, fire, drought, etc., extensive areas may be completely denuded, never to be reforested under natural conditions. Therefore it will evidently not be very long before it will pay to adopt insect-control policies in areas that are inaccessible for profitable lumbering.

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[a] If the broods develop to adults in the outer bark it must be burned; if they develop in the inner bark and are exposed when the bark is removed, burning is not necessary. As a rule the burning of the tops to destroy the insects is not necessary.

EXAMPLES OF SUCCESSFUL CONTROL OF BARK BEETLES.

The following examples of successful control of depredations by the destructive bark beetles are sufficient to demonstrate the practicability of advice based on the results of entomological investigations.

CONTROL OF THE EASTERN SPRUCE BEETLE.

The control of an alarming outbreak of the eastern spruce beetle (*Dendroctonus piceaperda* Hopk.) in northeastern Maine in 1900 and 1901 was effected by the concentration of regular logging operations in the areas of infested timber and placing the logs in lakes and streams and driving them to the mills on the Androscoggin River. Thus, with little or no additional expense, there was a saving to one firm, according to its estimates, of more than $100,000.

CONTROL OF THE BLACK HILLS BEETLE.

An extensive outbreak of the Black Hills beetle (*Dendroctonus ponderosæ* Hopk.) in the vicinity of Colorado Springs, Colo., in 1905–6, which was threatening the living pine timber of the entire section, was brought under control through the efforts of the private owners of forests and of officials in the adjoining national forests, by cutting and barking about 1,000 beetle-infested and beetle-killed pine trees. The cost of the operations was largely, if not entirely, covered by the utilized felled timber, although considerable unnecessary expense was involved through the felling and barking of trees from which the beetles had emerged, also from the unnecessary burning of the bark and tops.

The successful control of another serious outbreak of the Black Hills beetle in 1906 on an extensive private estate in southern Colorado was effected through the efforts of the owners, who had some 500 infested trees felled and barked within the necessary period to destroy the broods. A large per cent but not all of the infested timber was thus treated. So thorough was the work that not a single infested and dying tree could be found when the area was inspected in 1908. In this, as in the other case, considerable unnecessary expense was involved in the burning of the bark and tops, but the utilizable timber was worth more than enough to pay all expenses. It is evident that in this case a destructive invasion was prevented.

The most striking example of success in control of the Black Hills beetle has recently been reported. In May, 1907, Mr. W. D. Edmonston, a forest ranger, detailed from the Forest Service to the Bureau of Entomology, to work under our instructions in locations of beetle infestation in the national forests of Colorado and adjoining States, reported that the pine timber was dying on a large estate not far from Idaho Springs, Colo., and in the adjoining Pike National Forest. Mr. Edmonston was then instructed to make more detailed examinations, after which he reported that some 63,000 feet of standing timber on the estate was infested by the Black Hills beetle, and that unless the ravages were checked at once it would kill the timber not only on this estate but that on the adjoining estates and national forest. The owner of the property was advised by the Bureau of Entomology to take radical action, but no action was taken before the first of the following July, and therefore not in time to prevent the broods of beetles from swarming from the infested trees and extending their ravages.

In December, 1907, Mr. Edmonston was instructed to make another examination of the timber, when he found that his prediction was being fulfilled, and that instead of 65,000 feet of timber in the old infestation there was nearly four times as much timber involved in the new, or over 250,000 feet. The owner was again notified of the serious character of the outbreak, and further suggestion made that if the logs from the infested trees were converted into lumber and the slabs burned before May, 1908, it would result in the protection of the remaining living timber. Immediate steps were then taken by the owners to carry out the original recommendations. Mr. Edmonston gave instructions to the manager of the estate in locating and marking the infested trees and in the best methods of destroying the beetles; he also marked infested timber on an adjoining estate and on the national forest. Five months later, in May, 1908, Mr. Edmonston reported that the larger clumps of infested trees on the estate had been converted into lumber and the slabs burned, and that the marked trees on the adjoining estate and national forest had been cut and barked. In November, 1908, Mr. Edmonston was instructed to make another inspection of the forest on the estate and surrounding area, and on December 1 he reported:

> Nothing could be more satisfactory than the results obtained by the cutting of the infested timber on the estate. Your recommendations and instructions submitted to the owner, and carefully followed by the manager of the estate, have clearly demonstrated that insect infestation can be controlled and at no expense to the owner of the timber involved; in fact, a very satisfactory price was realized, resulting in a net profit, I understand, of $5 per thousand feet b. m. on the 240,000 feet cut. This, of course, does not include the profit of the milling operations, but for the logs sold at the mill, after deducting the expenses of cutting and logging. The sawmill was owned and operated by an Idaho Springs firm, and the manufactured article sold in that town. I spent six days on the estate, November 18 to 23. After a very thorough examination of the timber, I found only three infested trees, isolated individuals, and over a mile from where the large clumps of infested trees were cut. With the exception of those three trees, there is no new infestation on the estate. I also examined the adjoining lands, but no new infestation was observed. The infested trees which I marked in December, 1907, had been cut and barked. On the Pike National Forest, contiguous to the first-mentioned estate, where you will remember I marked some clumps of infested trees, no new infestation was found—not one tree. I found that all the infested trees I marked had been cut and barked. Ranger Kelso had charge of this work, and it has been quite thoroughly done.

This most gratifying result demonstrated two important things; one, that a quite extensive outbreak by one of the *Dendroctonus* beetles, involving near 1,000 trees, can be controlled without expense, and even at a profit, whenever the conditions are favorable for the utilization of the infested timber; the other that the essential details of the recommendations and expert advice based on the results of scientific research can be successfully applied by a manager of a private forest or by the rangers of national and state forests. It also indicates quite conclusively that the widespread depredations in the

Black Hills Forest Reserve could have been prevented with very little expense to the Government if the matter had received prompt attention in 1901, when the first investigations were made and essentially the same recommendations submitted. But, through the lack of public appreciation of the importance of the problem at the time, and the lack of sufficient authority and funds later, infestation was allowed to extend beyond practical control, and in consequence a large per cent of the timber of the entire national forest has been killed. There were then no forcible examples of the practical value of such recommendations based on scientific research, and no other argument was effective in arousing public interest in the threatening character of the outbreak. Now we have several examples demonstrating the practicability of forest-insect control in America which should lead to confidence in the results of research as a basis for successful practical application.

CONTROL OF HICKORY BARK BEETLE.

The complete control of the hickory bark beetle, whose ravages threatened the total destruction of the hickory trees on Belle Isle Park, at Detroit, Mich., in 1903, was effected by felling and removing the infested trees and converting them into merchantable products, all without cost to the park commission.

CONTROL OF INSECTS WHICH CAUSE DEFECTS IN LIVING TIMBER.

The class of insects which cause defects in the wood of living timber can be controlled to a greater or less extent, depending upon local conditions, and a large per cent of the losses can be prevented through the adoption of certain requisite details in forest management, especially (*a*) the utilization of all of the defective and infested timber that will pay expenses for manufacture into merchantable products, such as lumber, cordwood, etc.; (*b*) the burning of infested timber and waste material not available for use, including dead standing and down timber, to remove the breeding places of insects such as the oak timber worm and the chestnut timber worm, which insects go from the dead timber to the living; (*c*) the prevention of wounds of any kind in the bark of living trees; and finally (*d*) to prevent future losses by the practice of improved forestry methods, which will eliminate favorable conditions for injury and contribute to a perpetual supply of vigorous, healthy timber to be utilized before it passes the stage of profitable increment.

PREVENTION OF INJURY TO DYING AND DEAD TREES.

A large per cent of the injury to insect, fire, and lightning killed trees and trees killed or dying from injuries by storms, disease, etc., can be prevented—

1. By the prompt utilization of such timber within a few weeks or months after it is dead or found to be past recovery;
2. By removing the bark from the merchantable portions of the trunks within a few weeks after the trees are dead;
3. By felling the trees and placing the unbarked logs in water;
4. And, finally, by the adoption of a system of forest management which will provide for the prompt utilization of all trees which die from any cause.

PREVENTION OF LOSSES FROM INSECT INJURIES TO NATURAL AND ARTIFICIAL REPRODUCTION.

The successful control of insects which destroy or prevent the normal development of natural reproduction is a far more difficult problem than that presented by other classes of insect injuries, but in this, as in the others, a great deal can be accomplished toward preventing the reduction of future supplies.

Much can be accomplished in the nursery and on small plantations by the adoption of the ordinary methods of controlling farm and orchard insects, but in the natural forests reliance must be placed largely on systems of forest management.

UTILIZATION OF IMMUNE AND RESISTANT VARIETIES AND RACES OF TREES.

Certain individuals representing varietal or racial forms of trees of a given species are sometimes found to be either immune or decidedly more resistant to the insects which are destructive or seriously injurious to the life or wood of other individuals or varieties of the same species. This fact suggests the importance of recognizing the well-known principle of improvement by selection. Thus selecting seed or cuttings from such immune and resistant trees for artificial propagation, or taking great pains to leave such trees in commercial or selection cuttings, will undoubtedly be an important step toward providing against damage and losses in the future.

PREVENTION OF INSECT INJURIES TO FOREST PRODUCTS.

CRUDE PRODUCTS.

The problem of artificial control and prevention of insect injuries to forest products offers less difficulties perhaps than that relating to many other branches of the general subject of forest insect control.

In most cases the principle of prevention is the only one to be considered, since the damage is done soon after the insects enter the wood and therefore it can not be repaired by destroying the enemy.

Crude Products.

The degree of moisture found in the bark and wood of newly felled trees, saw logs, telegraph poles, posts, and like material cut in the fall and winter and left on the ground or in close piles during a few weeks or months in the spring and summer, or during the period when the particular species of injurious insects are flying, is one of the conditions most favorable to attack. This period of danger varies with the kind of timber and the time of the year when felled. Those trees felled in late fall and winter will generally remain attractive to ambrosia beetles and the adults of round and flat headed borers during March, April, and May. Those felled during the period between April and September may be attacked in a few days after they are felled, but the period of danger may not extend over more than a few weeks. Thus certain kinds of trees felled during certain seasons may never be attacked, while if felled at other seasons the conditions for attack may be most favorable if insects are active, and then the wood will be thickly infested and ruined. The presence of bark is absolutely necessary for successful infestation by most of the wood-boring grubs, because the eggs and young must occupy the inner and outer portions before the latter can enter the wood. Some ambrosia beetles and timber worms will, however, attack barked logs, especially those in close piles or otherwise shaded or protected from rapid drying. A large per cent of the injury to this class of products can be prevented—

1. By providing for as little delay as possible between the felling of the tree and its manufacture into rough products. This is especially necessary with trees felled from April to September in the region north of the Gulf States and from March to November in the Gulf States, while the late fall and winter cuttings should all be worked up by March or April;

2. By removing the round timbers from the woods and skidways during the danger period, or if this is impossible, by taking every precaution to facilitate the rapid drying of the inner bark by keeping the logs off the ground, in the sun, or in loose piles; or else the opposite extreme should be adopted and the logs kept in water;

3. By the removal of the bark from poles, posts, and other material which will not be injured by checking or season cracks, within a few days after the trees are felled;

4. By working in the proper months or seasons to fell or girdle different kinds of trees.

Damage to products cut from saplings and left with the bark on can be prevented by transporting the material from the woods soon after it is cut, so it will not be left in piles or bundles in or near the forest during the season of insect activity, also by frequent change of place of storage.

Pin-hole damage to stave and shingle bolts cut during a warm season can be prevented by removing the bark from the timber as soon as it is felled and by converting the bolts into the smallest practicable dimensions and piling them in such a manner as to facilitate rapid drying.

Damage to unseasoned handle and wagon stock in the rough can be prevented by taking special precautions to provide against the same favorable conditions for attack as mentioned in connection with round timbers. This is especially necessary with hickory and ash if cut during the winter and spring.

Damage to pulp wood and cord wood can be prevented to a great extent by placing the sticks in triangular or crib piles immediately after they are cut from the trees, especially if the timber is cut during the danger period or must be held over a few months during the warm season. Peeling or splitting the wood, or both, before it is piled will also provide against damage from insects.

Manufactured Products.

UNSEASONED PRODUCTS.

Freshly sawed hard-wood lumber placed in close piles during warm damp weather, within the period from July to September, inclusive, presents the most favorable conditions for injury by ambrosia beetles. In all cases it is the moist condition and retarded drying of the lumber which induces attack. Therefore any method which will provide for the rapid drying of the lumber before or after piling will tend to prevent losses. It is important also that heavy lumber should, as far as possible, be cut only in the winter and piled so that it will be well dried out before the middle of March.

The damage to lumber and square timber when the bark is left on the edges or sides can be prevented by removing the bark before or immediately after the lumber is sawed, or by sawing and piling the material during the winter, or if sawn at other times, piling it so as to facilitate rapid drying.

SEASONED PRODUCTS.

Unfinished seasoned products.—Injury by powder-post beetles to dry hard-wood lumber and other material in stacks or storehouses can be prevented—

1. By a general inspection of the material in the yards and storehouses at least once a year, preferably during November or February, for the purpose of sorting out and disposing of any material that shows the slightest evidence of injury, as indicated by the presence of fine powdery boring dust;

2. By preventing the introduction into lumber yards or storehouses of any infested material, remembering that the insect may be thus distributed to all parts of the world;

3. By the adoption of a system of classification of all dry or seasoned hard-wood stock which will provide for (*a*) the separation of the pure heartwood material from the pure and part sapwood material; (*b*) classification of all kinds of wood most liable to attack, such as hickory, ash, oak; (*c*) the successive utilization or sale of the older material (remembering that material one year old or over is far more liable to injury); and (*d*) providing against the accumulation of refuse material in which the insects could breed.

Finished products.—Damage to finished handles, oars, spokes, rims, hubs, wheels, and other unpainted wagon, carriage, machinery, and implement stock in factories, wholesale and retail storehouses, army and navy stores, can be prevented by the adoption of the same general rules as those given under rough products. In addition, damage can be controlled and prevented—(*a*) by sorting out and destroying all articles showing the slightest evidence of powder-post injury, or (*b*) treating with kerosene oil such infested and slightly injured articles as may be tested for required strength and found to be of sufficient value to retain, the same to be placed in quarantine a sufficient length of time to determine whether the treatment is successful.

Damage by insects to many articles can be prevented, and at the same time the material benefited, by treating the wood with linseed oil, either by immersion in the oil or by application with a brush, the application to be made as soon as possible after the articles are finished.

PAST AND PRESENT CONDITIONS OF POWDER-POST INJURY.

Up to 1906 there were a great many reports of extensive losses of valuable material from the extensive ravages of powder-post beetles, which were seriously affecting all industries involved in the manufacture, sale, and utilization of the classes of hard-wood products. In response to these reports and accompanying appeals to the Department of Agriculture for information on causes and remedies, the problem was thoroughly investigated, and specific advice and instructions relating to practical methods of control and prevention have been widely disseminated, both through publications of the department and special correspondence.

Reports of present conditions, with fewer requests for advice, indicate that the disseminated information has been extensively utilized and that it has been worth many millions of dollars toward eliminating the losses and reducing the drain on the limited supply of the kinds of timber required to replenish the damaged and destroyed material.

The army and navy stores of handles, tent poles, wheelbarrows, oars, and many other hard-wood articles have suffered severely from powder-post damage, but the information supplied has contributed greatly toward the elimination of this source of loss to the Government.

TAN BARK.

Damage to hemlock and oak tan bark by the class of insects which in some cases have been so destructive to this class of products in the past can be easily prevented without cost—

1. By utilizing the bark within three years from the time it is taken from the trees;
2. By preventing the accumulation in the yards and store sheds of old waste material in which the insects can breed.

These simple methods have been extensively adopted since their recommendation in correspondence and publications between about 1894 and 1904, and constitute one of the most striking examples of the value of expert information on the peculiar habits of insects and of how millions of dollars can be saved by exercising a little judgment.

UTILIZED PRODUCTS.

Damage and losses from insect injuries to timber and other woodwork in structures of various kinds, to telephone and telegraph poles, posts, railroad ties, mine props, etc., can be prevented by treating the material with preservatives.

TIMBERS AND WOODWORK IN STRUCTURES.

Injuries to timbers and woodwork in dwellings, outbuildings, bridges, etc., by powder-post insects can be prevented—

1. By the use of heartwood only for the concealed parts most liable to be damaged;
2. If it is necessary to use all or part sapwood material, attack can be prevented by treating the sap portions with kerosene, coal tar, creosote, or linseed oil. Facilities for future treatment can be provided wherever the rough or finished woodwork is exposed, as in outbuildings, bridges, etc., if care is taken to expose the sapwood portions;

3. If the timbers and woodwork in old buildings show evidence of attack, the affected portions should be treated with a liberal application of kerosene.

Damage by white ants or termites can often be prevented—

1. By the use of sound wood only for underpinning and foundation timbers and the removal of decaying timbers from old structures;
2. By preventing abnormal moist conditions of the wood in any part of the structure, and especially of that in foundation timbers;
3. By the treatment with creosote, zinc chloride, corrosive sublimate, etc., of timbers necessarily exposed to moist conditions;
4. If the timbers become infested, further injury can be prevented by removing the badly damaged parts and soaking the remainder with kerosene, fumigating with bisulphide of carbon, and by removing any adjacent wood in which the insects may breed, such as logs, stumps, etc.

LOG CABINS AND RUSTIC WORK.

Damage by bark and wood boring insects to the unbarked logs and poles used in rustic cabins, summer houses, fences, etc., can be largely prevented by cutting the material in October and November and utilizing it at once, or by piling it off the ground or under cover in such a manner as to offer the best facilities for the rapid and thorough drying of the inner bark before the middle of March or the first of April following. If this precaution is not taken and there is evidence that insects are at work, the damage can be checked by injecting bisulphide of carbon through natural or artificial openings in the affected bark and immediately stopping these and other openings with putty or a similar substance.

POLES, POSTS, TIES, MINE PROPS, AND SIMILAR PRODUCTS.

Insect damage to poles, posts, and similar products can be prevented to a greater or less extent by the preservative treatments which have been tested and recommended by the Forest Service. These should be applied before the material is utilized, or if attacked after it has been utilized, further damage can be checked to a certain extent in like manner.

It is of prime importance to prevent injury from wood-boring insects because such injuries contribute to more rapid decay.

UTILIZATION OF NATURAL ENEMIES OF INJURIOUS INSECTS.

Were it not for the natural checks of control of some of the more destructive insect enemies of forest trees and products, successful artificial control would, in many cases, be impossible, and the depredations would be far more complete. These natural enemies of the depredating insects consist of parasitic and predatory insects, diseases of insects, birds, adverse climatic conditions, etc. While one or more of these beneficial factors exerts a continuous and powerful influence toward the prevention of a more extensive waste, it has been repeatedly demonstrated that these checks can not always be depended upon to prevent widespread devastations by protecting the best trees and the best tree species. The insects and birds which prey upon the depredating insects also have enemies consisting of insects, birds, diseases, and climatic conditions. Therefore under normal conditions the tendency is toward the preservation of a balance between the warring factors, but frequently the enemies of the trees get the ascendency and take the character of an invasion, which may continue for two or three or even ten years before the balance is restored. Thus a vast amount of timber or a given forest product may be destroyed before the factors of natural control can prevail.

It is evident that the most effective utilization of the factors of natural control will be through our assisting in the destruction of the enemy rather than through the artificial introduction of such factors. The former is accomplished by the adoption of methods of combating the invaders which will reduce their forces below the power of attack, or by reducing their numbers to the point where they must occupy a defensive position against their natural enemies and become dependent for their supplies of food and breeding places upon that avoidably furnished through mismanagement of the forests and manufacturing operations. Thus we can contribute greatly toward the preservation of a balance which will be to our material benefit. On the other hand, we may in the future, as we have in the past, contribute greatly to the multiplication of the depredating insects and to greatly increased losses caused by them through ignorance or disregard of the fundamental principle of insect control in the management of forest and manufacturing enterprises.

BENEFICIAL INSECTS.

The beneficial insects comprise those which are internal or external parasites of the immature or matured stages of the injurious insects, also those which feed on the young or adults. These two classes are doubtless far more effective in the long run than any other set of agencies of natural control. Yet they, in combination with all other factors, can not be always relied upon to render the desired service of continued and efficient control. They can, however, be relied upon to respond to artificial assistance in the reducing of the depredators or to proper artificial introduction and distribution.

BENEFICIAL DISEASES OF INSECTS.

It is very evident that the parasitic fungi and bacteria which sometimes cause epidemics among injurious insects often exert a powerful influence toward the control of extensive outbreaks or invasions of insect enemies of forests. Indeed, it appears that the greatest service rendered by this class of natural enemies is in the often sudden appearance of an epidemic which kills off a destructive species of insect, which has increased to such numbers and extended its depredations over such vast areas as to be far beyond the control of man or his insect and bird allies. Numerous examples of this kind of natural control are found in widespread depredations by various species of caterpillars and sawfly larvæ which defoliate deciduous and coniferous trees. As a rule, however, the beneficial effects of the diseases of insects prevail only after the injurious insects have increased to excessive numbers. Therefore this factor of insect control can not be depended upon to hold the insects in check or prevent outbreaks. The fact, however, that it operates on a class of insect enemies of the forest (defoliators) which can not be controlled by any known artificial methods renders the services of the diseases all the more valuable.

It is believed that with further knowledge of nature's method of propagating, perpetuating, and disseminating epidemics among insects, they can be utilized more or less successfully through artificial propagation and dissemination to head off threatened invasions by defoliating insects.

BENEFICIAL BIRDS.

That certain classes of birds, such as woodpeckers, render valuable service toward the natural control of certain destructive bark and wood boring insects is very evident. They appear to render the greatest service, however, where but few trees are being killed or injured, because their concentrated work on such trees may contribute toward the prevention of an abnormal increase of the insects. They also render some service as allies of the other beneficial factors which assist in artificial control. It is evident, however, that where many hundreds or thousands of trees are being killed, the comparatively limited number of birds in any forest under the most favorable conditions can have little beneficial effect. Therefore, while the birds should be classed among the valuable friends of the forest and should be protected, it is plain that they can not, even with the utmost protection, always be relied upon to protect the forest against destructive ravages of insects.

We must remember in this connection that there are complicated interrelations between birds, injurious insects, and beneficial insects which do not necessarily operate to the benefit of the forest. In fact, it may sometimes happen to be quite the reverse. Therefore, in order to derive the greatest benefit from the conflict between the birds, the insect enemies of the trees, and the insect friends of the trees, we must utilize our knowledge of the factors which are contributing toward the preservation of a balance, so that whenever the enemies of the forest threaten to get beyond natural control, we may enter the field and through artificial means endeavor to force them back to their normal defensive position.

BENEFICIAL CLIMATIC CONDITIONS.

The benefits to be derived from climatic conditions which are detrimental or destructive to insect enemies of the forest, while sometimes very great, are necessarily unreliable and thus can not be depended upon to assist in artificial control. In fact, the very condition which may contribute to the destruction of one depredator may favor the multiplication of another.

UTILIZATION OF WASTE CAUSED BY INSECTS.

When we come to consider the vast amount of standing timber in the forests of the country which has been injured or killed by insects, and which will go to waste if it is not utilized within a limited period, we realize the importance of removing the insect-infested timber, because in doing so we contribute more, perhaps, than in any other way to the reduction of the insects, and thus provide against serious injury in the future, as well as to the maintenance of control.

PRESENT CONDITIONS AND OPPORTUNITIES.

Unfortunately, the examples of management, or rather mismanagement, which are contributing to an increase of waste are far in excess of instances of proper management. This is due in a large part to the conditions that have prevailed in American forests in the past which have rendered it impracticable to adopt improved policies of forest management, but at present it is largely due to a lack of appreciation of the importance of the subject, and of the opportunities to prevent such losses, when it is not only practicable, but possible, to do so, and will at the same time yield large returns on the necessary additional expense. This is especially true in thousands of farmers' woodlots and private holdings in the States east of the Mississippi River, in which from 25 to 90 per cent of all of the serious injury of the past can be prevented in the future with little or no additional expense over that required for ordinary good forest management.

FOREST ENTOMOLOGY, AS APPLIED TO AMERICAN FORESTS.

It is only within the past eleven years that any attempt has been made toward a systematic investigation of the insect enemies of the forest trees and forest products of the entire country. The state of knowledge of the subject previous to that time can be judged by the fact that a number of the most destructive enemies of forest trees are found to be new to science and that nothing whatever was known of the habits and seasonal history of a large number of the more important known species which are common enemies of forest trees and forest products, and that scarcely anything was known in regard to practical methods of controlling the enemies or of preventing losses from their ravages.

PRESENT KNOWLEDGE.

Within the past ten years forest-insect investigations have been conducted by the Bureau of Entomology of the Department of Agriculture in all of the principal forest regions of the United States, which have led to the following results:

RESULTS OF INVESTIGATIONS.

Satisfactory progress has been made toward the attainment of some of the fundamental objects of the investigations, one of which has been the laying of a substantial foundation for forest entomology in this country, on which future progress can be made along the lines of acquiring, disseminating, and applying information of immediate practical value in the protection of our forest resources.

ACQUIRED OR NEW INFORMATION.

The principal insect enemies of the forest and forest products of North America and the general character and extent of their depredations have been determined.

The more important facts in the life history, habits, and practical methods of control relating to some of the more destructive insects have been determined.

A mass of original data has been collected relating to forest insects in general, including not only those which are destructive or injurious, but those which are beneficial or neutral in their relation to [illegible] forest, as represented by a collection of more than a million specimens of insects and their work.

As a direct result of the investigations of forest insects during the past six years, at a cost of less than $53,000, there has been accumulated a reserve fund of information now available through publications, correspondence, and field demonstrations, which, if properly utilized for practical application, would evidently prevent from 10 to 30 per cent of the annual losses at a very small cost.

DISSEMINATED INFORMATION.

In addition to information disseminated to all sections of the country through correspondence, lectures, demonstrations, exhibitions, etc., the published information, based on the results of investigations conducted by the West Virginia Experiment Station and the Bureau of Entomology of the U. S. Department of Agriculture during the past eighteen years is represented by over 1,300 pages, 99 plates, and 340 figures.

NEEDS.

The work that has been done is only a beginning in the vast field of forest entomology. There is need of more systematic work (or so-called pure science) on the different stages of the thousands of species of injurious and beneficial insects involved. This is absolutely necessary in order to have further scientific basis of facts on which to build the structure of complex details necessary to success in practical application in its broadest sense.

There is need of further detailed studies of habits and seasonal histories of the species of injurious and beneficial insects, as well as of the local and other conditions favorable and unfavorable for their multiplication and work.

Further information is desirable on the principal factors of natural control, in order that it may be better utilized to facilitate artificial control.

There is special need of more general information on, and public interest in, the subject of losses from insect depredations on standing timber and timber products, and a better realization of the possibility and practicability of preventing losses.

Looking to this end, there is need of further demonstration and educational work along the lines which will bring the matter to the attention of the man in the woods, sawmill, factory, or trade, who is in direct touch with the local conditions and business methods.

There is a special need of more experts in forest entomology, and there will be an increasing demand for such experts in the future to organize and take charge of insect-control policies in state forests, public parks, the more extensive private or commercial forests, and in extensive manufacturing enterprises, and also to give instructions to students in forestry schools and forestry departments in state and other institutions of learning.

The need of trained and experienced experts in forest entomology for all of this class of work can not be too strongly urged. There is, perhaps, no branch of economic or applied science which requires more technical knowledge and practical experience as a basis for proper investigations and authentic instructions and advice than forest entomology, and there is perhaps no other feature in the science and practice of forestry in which advice and application based on insufficient knowledge is so dangerous.

There is quite general recognition of the importance of guarding against contagious diseases, and of consulting a physician in a case of serious illness, and of the necessity of relying on an authorized pharmacist to fill a prescription, and of administering the prescribed treatment according to directions, but it is a notable fact that comparatively few persons, even when deeply interested in preserving the health of the forest, have heretofore recognized the importance of guarding against insect epidemics or of consulting an expert forest entomologist in the case of threatened or existing depredations. It has often happened that when such advice has been sought and received, the treatment was not administered according to the recommendations, but changed to suit the ideas of some one entirely ignorant of the facts and principles on which it was based. Thus not only the accomplishment of the desired results failed, but often contributed to an aggravation of the trouble and increased losses. The determination of the causes of specific troubles affecting the individuals of a given species of forest tree or an injury to a given type of product is just as complicated and requires the same elements of experience, training, and skill as that required for the determination of the cause of a given disease or the character of a given injury affecting man, and it is just as important to know the cause or character of injury in the former as it is in the latter, in order to prescribe the specific treatment which will yield the desired results.

Therefore, in order to make the best progress toward preventing future waste of our forest resources from depredations by insects, every one interested in the subject, and especially those in authority in public and private institutions of investigation and learning, should see to it that the character of instructions to students and of the information given out to the public is not only the best available, but that it is limited to the range of expert knowledge of the subject possessed by the instructor or investigator.

ELEMENTARY AND TECHNICAL KNOWLEDGE OF FOREST ENTOMOLOGY FOR THE FORESTER.

While it may be desirable that every professional forester should have an expert knowledge of forest entomology, it is rarely possible except under certain favorable conditions for him to acquire more than the necessary elementary knowledge, and even this has not been possible under the conditions which have necessarily prevailed in the forest schools and in the practice of forestry in this country, and little or no time has been available for acquiring the necessary information from subsequent study or experience. Therefore this feature in the education of the American forester has been practically neglected.

PRESENT REQUIREMENTS OF INSTRUCTION.

As long as expert forest entomologists and authentic text-books based on American insects and conditions are not available for giving a complete course in technical and applied forest entomology, the requirements of such a course should be limited to instruction in elementary entomology and elementary principles of applied forest entomology, which will give the necessary foundation for intelligent observations and utilization of available information as required in future practice.

SUMMARY.

There is conclusive evidence that insects have been in the past, and are now, important factors in the waste and reduction of timber supplies, and will continue to be in the future.

They attack perfectly healthy trees of all ages and kill them.

They have killed a large per cent of the best timber over thousands of square miles of heavily forested lands.

They reduce the value of living timber and that of crude, finished, and utilized products.

HOW LOSSES CAN BE PREVENTED.

The results of extensive investigations and of practical applications during recent years have demonstrated that some of the most destructive insect enemies of American forests, and of manufactured and utilized products, can be controlled and serious damage prevented with little or no ultimate cost over that involved in good forest management and business methods.

It is evident that if the information now available through publications of the Department of Agriculture and through direct correspondence with its experts is properly utilized in the future, it will result in the prevention of an equivalent of at least 30 per cent of the estimated annual waste of forest resources caused by insects, and thus contribute greatly to the conservation of forest resources.

This can be accomplished—

(1) By the adoption or adjustment of certain requisite details in forest management, lumbering and manufacturing operations, and in storing, transporting, and utilizing the products which adoption, at the least expense, will bring about the necessary reduction of injurious insects and prevent their future multiplication or destructive work.

(2) By the adoption of policies of control based upon expert technical knowledge or advice relating to the species, habits, life history, and natural enemies of the insects involved, supplemented by knowledge of the proper management, care, and utilization of the forest and its resources, and by practical knowledge and experience relating to local conditions and facilities.

(3) Reliance on technical advice furnished by recognized experts in forest entomology and forestry as a basis for success in practical application by the owner or forester.

(4) Utilization of so-called matured timber, and especially of dense or pure stands of such timber, thus removing one of the favorable conditions for rapid deterioration through attacks by wood-boring

insects or the death of the timber through the attack of destructive bark-boring or defoliating insects.

(5) As a rule, it is useless to attempt the extermination of an insect enemy of the forest or its products. It is only necessary to reduce and weaken its forces, so that it can not continue an aggressive invasion, but must occupy a defensive position against its own enemies and become dependent upon conditions resulting from avoidable negligence and mismanagement by the owners of the forests and the manufacturers of forest products.

(6) The utilization of a knowledge of the principles of natural control as a means of contributing to the efficiency of artificial control.

(7) Prompt recognition of the first evidences of a destructive outbreak of the principal insect depredators, authentic identification of the species involved, and prompt action in adopting the proper method or methods of control.

While beneficial insects, beneficial birds, and beneficial diseases exert a continuous and powerful influence toward the prevention of a more extensive waste of forest resources, it has been repeatedly demonstrated that they can not always be depended upon to prevent widespread devastations or to otherwise work for the best interests of the private or public owner by protecting the best trees and the best tree species.

The best way to utilize the factors of natural control is to become their allies and assist in the reduction of the enemy, rather than to try to make them our allies through artificial introduction or dissemination.

A large percentage of the timber injured by insects can be utilized which will, at the same time, without additional expense, contribute greatly to the control of insects which cause waste, and also prevent injuries and depredations in the future.

Under past conditions the poor management or neglect of the average forest has contributed to the increase of depredations by insects.

Under present conditions of better management of local forests and the more progressive manufacturing enterprises, considerable is being accomplished toward the reduction of losses, but in the average forest, and the average business enterprise dealing with forest products, present conditions are little better than in the past.

This is largely due to a lack of appreciation of the importance of the subject and failure to realize the opportunity and practicability of preventing a large per cent of the losses.

CONSERVATIVE TURPENTINING.

By Geo. B. Sudworth,
U. S. Forest Service.

NATURE OF NAVAL STORES.

Naval stores, so called, consist of commercial "spirits of turpentine" or turpentine, rosin, and tar. All are derived chiefly from the resin of pines, but may be derived also from that of such related conifers as the spruces (Picea) and the false hemlocks (Pseudotsuga). Pines gave these supplies in the early history of this industry, as they do now in both this and in European countries. Turpentine and rosin constitute the principal and most valuable products known as naval stores. Pine "tar" or "pitch," once the principal product and so extensively used for rendering marine vessels water-tight, plays but a very small part now in naval-stores production. The present term "naval stores" dates from the use of pine tar in the days of wooden and other ships.

REGION PRODUCING NAVAL STORES.

Naval stores are produced now almost entirely in the South Atlantic and Gulf States. Southeastern Virginia, eastern North Carolina, and South Carolina originally yielded this country's naval stores. They are produced now chiefly by Georgia, Florida, Alabama, Mississippi, Louisiana, and eastern Texas, but very little comes from the last-named State. The center of production is in Florida, formerly having long been in Georgia. The seat of greatest production is likely to be next in the region of Louisiana, Mississippi, and Texas, on which, after the exhaustion of Florida's pine forests, production must depend.

SPECIES OF PINES YIELDING NAVAL STORES.

The longleaf pine (Pinus palustris) and Cuban or "slash" pine, which are pitchy, hard-wooded pines, yield the naval stores of our commerce. Practically all of the other native pines are capable of producing naval stores, but they are not now worked. The near future will unquestionably see at least two or three other southern pitch pines added to the list of producing species, as well as one or two species of western pines. It is not likely that the "white" or soft-wooded pines will ever be resorted to as producers of naval stores.

HOW NAVAL STORES ARE OBTAINED.

GUM SPIRITS OF TURPENTINE AND ROSIN.

Naval stores were first derived by charring or burning the wood of pitch and other pines in rudely constructed pits or kilns. The product then was pitch only, because charring the wood consumed or liberated as waste the volatile turpentine. Naval stores are now produced by distilling the crude resin obtained from living longleaf and slash pines. The principal product, turpentine, is driven off in steam in a simple copper "still," the turpentine being collected with the water after condensation. The residue, cleared of all impurities by straining, is commercial rosin. No other products are yielded.

WOOD SPIRITS OF TURPENTINE.

Various patented processes, which subject the ground or otherwise reduced "fat" wood of longleaf and slash pine stumps, waste logs, and butts to steam or destructive heat applied to or in closed retorts, produce a form of turpentine, which, when refined, has practically the same commercial qualities as that distilled from crude gum or resin.

This means of obtaining turpentine is comparatively new and still subject to considerable improvement. The steam processes have so far produced a purer grade of turpentine than any of the processes which carry distillation to the point of charring the wood. Much of their products require redistillation to obtain a pure grade of turpentine; but they derive, in addition to turpentine, charcoal, and a residue of heavy pine-tar oil mixed with other ingredients not obtained by the steam processes. The charcoal is, however, practically a waste product, because usually it is too far from a market, while as yet there is very little profit derived from the sale of the heavy tar products.

SOURCE OF CRUDE RESIN.

PRELIMINARY DISCUSSION.

It seems probable that much of the production of naval stores will be dependent in the future, as it has been in the immediate past, upon the production of crude resin from living trees.

The utilization of the waste products of lumbering, such as stumps and other "fat" portions of the trees for the production of wood spirits of turpentine, appears likely to be carried at once to a proper degree of strict economical use. But the magnitude of this utilization depends rather upon the enormous lumbering waste of the past than upon that of any system of lumbering now in vogue or likely to be in the future. The supply of dead and down "fat" pine waste obtainable now is considerable, but it is clearly exhaustible within comparatively few years. No such supply can be looked for even in the immediate future, and certainly not in the distant future, both for the reason that the enormous supply of southern pine timber once available is now very largely lumbered out, and because the intensely conservative lumbering of the present and future will leave comparatively little for the wood distilling turpentine plant. The product, therefore, of wood spirits of turpentine can be safely put down as a small part of the country's total naval stores product. Production of wood spirits must then depend entirely upon the use of mill waste, and very much shorter stumps than old systems of lumbering are now affording. Mill waste yields approximately only about one-fifth as much turpentine as the heavy "fat" pine waste logs and high stumps which are worked entirely now for wood spirits.

HOW CRUDE RESIN IS OBTAINED.

The first method of obtaining crude resin was to cut a deep pocket or "box" in the base of the tree for the purpose of collecting the resin which flowed from cuts made in the tree's trunk just above the box. New cuts, "streaks," were made, one above another, each week in order to stimulate a fresh flow of resin, which dripped from the edge of the new cut "chip" into the box. The box held about three pints of resin, and at the end of every four weeks this was "dipped" out by means of a thin, flat, spade-like tool called a dipper.

The weekly chipping proceeded from March to September, when the resin would no longer flow readily. Each tree was usually worked, "turpentined," for four or five seasons, when it was abandoned.

At the end of four or five years the aggregate chipping done to each tree was equivalent to cutting off from two to six slabs (three-fourths of an inch to 2 inches deep) from two or three sides of the tree. The breadth of these slabs was from 8 to 12 inches and from 5 to 7 feet in height. Large trees were thus often practically stripped of their outer layers of living or "sap" wood. Moreover, the depth and width of the box was so great as to actually cut away from one-third to two-thirds of the tree's thickness at the base. The trees were thus so weakened that heavy wind storms easily threw them in large numbers. (See fig. 1.)

AREA OF PINE FOREST PRODUCING NAVAL STORES.

Originally the longleaf and slash pine forest, capable of, and in part, yielding the naval stores of this country, included southeastern Virginia, the coastal plain of North Carolina, South Carolina, Georgia, Florida, Mississippi, Louisiana, and the eastern border of Texas. (See figs. 2 and 3.)

But the area now producing naval stores is very much less, being confined practically to the extreme south border counties of Georgia, to Florida, to limited areas in southern Alabama, to Mississippi, to Louisiana, and to a considerably less extent to eastern Texas. Virginia's and the Carolinas' original pine forests, being nearly or quite exhausted, are now practically out of the producing belt, while eastern Texas forests, still largely intact, are really not yet in the producing belt. This is because of a prejudice among Texas timber-land owners against "turpentining" their pine, and also because they fear the added danger of fire to their timber, which must be specially protected in a turpentined forest. Their belief is that working the trees for naval stores reduces the market value and price of the lumber cut from such trees beyond all profit realized from the turpentine operations. The same belief is shared also by some pine-timber

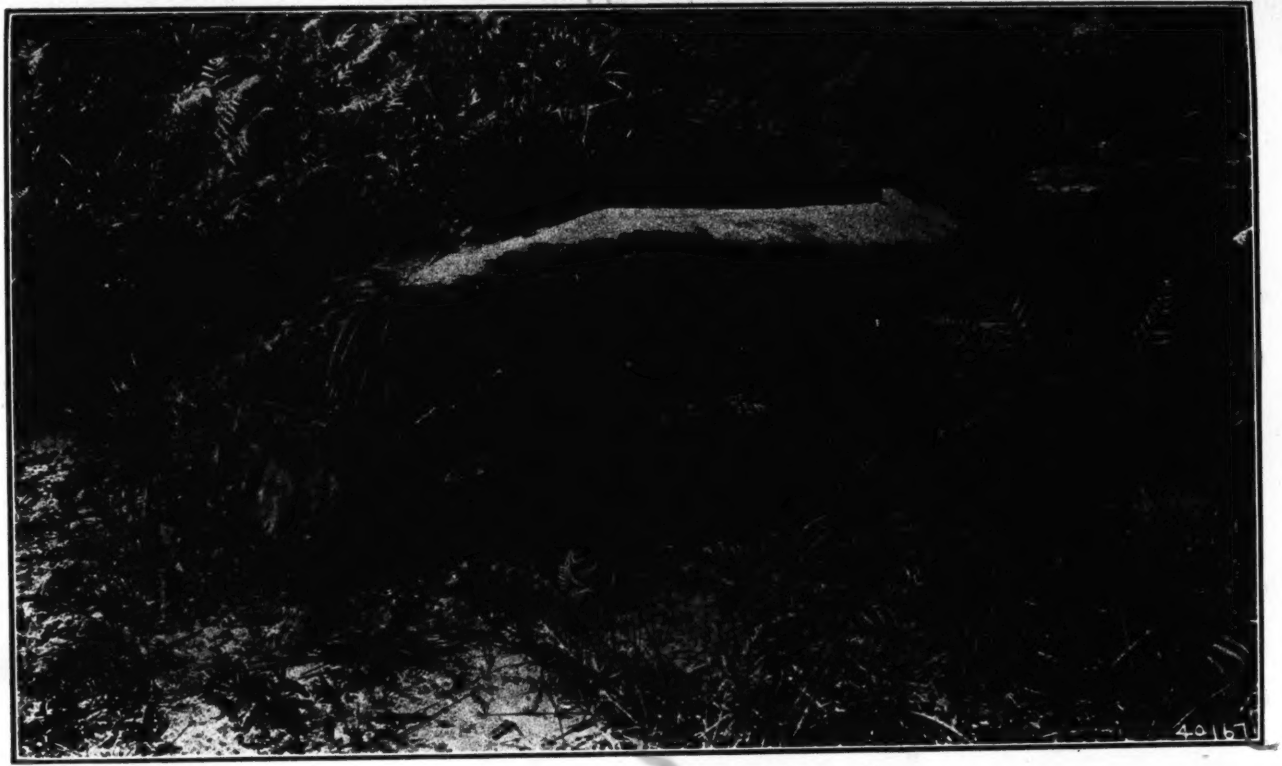

FIG. 1.—FALLEN TREE, TOO MUCH BOXING. NEAR OCILLA, GA.

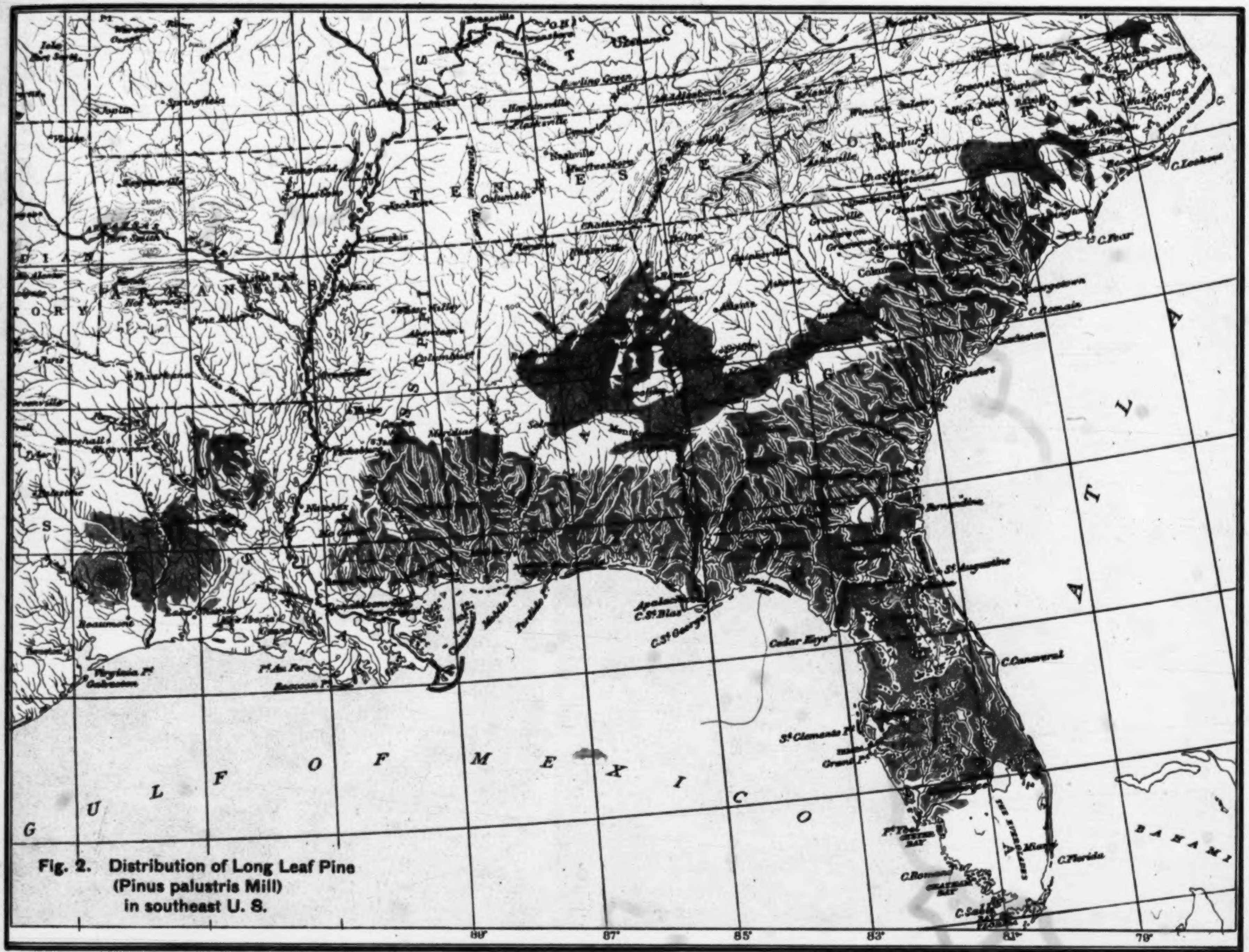
GULF OF MEXICO
ATLANTIC
TENNESSEE
NORTH CAROLINA
ARKANSAS
Memphis
Nashville
Chattanooga
Atlanta
Charleston
Savannah
Fernandina
St Augustine
C. Canaveral
C. Florida
Miami
C. Sable
Cedar Keys
C. St George
C. St Blas
Apalachicola
Mobile
Pensacola
Galveston
Beaumont
Natchez
Vicksburg
Little Rock
Pine Bluff
Hot Springs
Joplin
Springfield
Bowling Green
Asheville
Raleigh
Wilmington
C. Fear
C. Lookout
C. Romain
Georgetown
Columbia
Greenville
BAHAMA
89°
87°
85°
83°
81°
79°

Fig. 2. Distribution of Long Leaf Pine (Pinus palustris Mill) in southeast U. S.

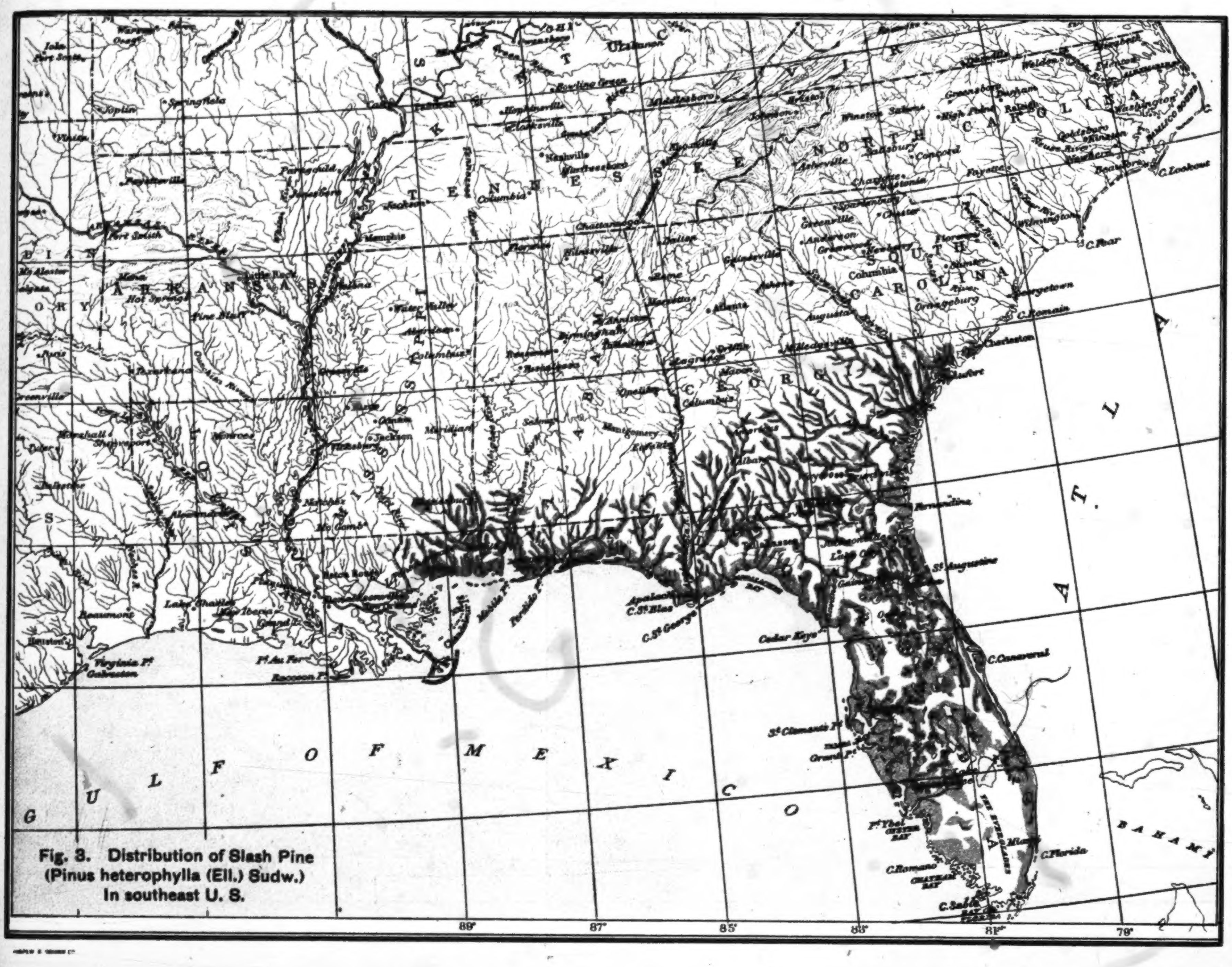

Fig. 3. Distribution of Slash Pine (Pinus heterophylla (Ell.) Sudw.) In southeast U. S.

TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
ARKANSAS
VIRGINIA
KENTUCKY
GULF OF MEXICO
ATLANTIC
BAHAMA
Nashville
Memphis
Chattanooga
Knoxville
Atlanta
Birmingham
Montgomery
Columbus
Macon
Augusta
Columbia
Charleston
Savannah
Wilmington
Jackson
Vicksburg
Natchez
Baton Rouge
Mobile
Pensacola
Apalachicola
Tallahassee
Jacksonville
Fernandina
St. Augustine
Cedar Keys
Gainesville
Little Rock
Hot Springs
Pine Bluff
Shreveport
Beaumont
Houston
Galveston
C. Hatteras
C. Lookout
C. Fear
C. Romain
C. St. George
C. Canaveral
C. Florida
C. Romano
C. Sable
Miami
Lake Charles
New Iberia
89°
87°
85°
83°
81°
79°

owners in Louisiana and Mississippi. In the latter States this prejudice has prevented, until within the last five years, the rapid and complete establishment of naval stores production in that region. It is beginning to advance there now, through extensive combined lumbering and naval stores operations, and is likely within the next decade to become fully established throughout the longleaf pine belt.

The still quite general, unrelenting prejudice of Texas pine-timber owners is keeping the longleaf-pine forest of that region out of naval stores production, except in a few localities.

REGION OF GREATEST NAVAL STORES PRODUCTION.

Georgia, Florida, and Alabama, with Florida in the lead, now produce the bulk of our naval stores. Mississippi and Louisiana are next in point of production. Normally these five States, with Texas, should constitute the region of largest production. It is most probable, however, that the center of production, now in Florida, will move westward into the Mississippi River States. With the present generally wasteful methods of working the forests, this movement may take place within the next twenty-five years, or possibly sooner, owing to the present extremely rapid and exhaustive spread of the production in Florida.

CONDITION OF FORESTS PRODUCING NAVAL STORES.

Of the pine forest now yielding or being worked for naval stores 87½ per cent is being worked by the ancient, destructive box system. Twenty per cent of this timber is passing the point of production, while the remaining 80 per cent is at the height of its productiveness and will cease yielding within two years. Of this producing forest 20 per cent has been more or less burned, which means that the total possible production has not only been appreciably reduced, but that as a result of burning the turpentined tree trunks, the commercial quality of lumber available from this timber is also degraded. Charring the chipped or turpentined trunks produces extensive pitchy areas in approximately 8 to 10 per cent of the saw timber. The total loss from this damage is conservatively estimated at 5 per cent. It is believed to amount to from 5 to 10 per cent, for the damage involves 12 to 15 per cent of the best part of every merchantable tree.

It is estimated that 5 per cent of the forest, yielding or being worked for naval stores under the old box system of turpentining, is either dead or thrown down as a direct result of the severe cutting necessitated by this method. (See fig. 1.) This amount may be safely reckoned as total loss, since the scattered and isolated occurrence of areas so affected are not usually reached by lumbering operations before the timber is badly affected by decay and wood-boring insects.

The remaining 12½ per cent of forest yielding naval stores is being worked under an improved system of turpentining known as the "cup and gutter" or "cup and apron" method. No deep box is cut at the base of the trunk, and the turpentined pine trunks are injured only as a result of the season's chipping, which is on the whole as severe as that resorted to under the box system. The timber is, however, not in danger of being thrown by storm, because the trees are not weakened by deep boxes at their bases. This type of timber is relatively in thriftier condition than that worked under the box system, because it has received less injury. It is, moreover, as a rule unburned, for the reason that the intrinsic value of the cup and gutter outfit (liable to destruction by fire) compels greater protection against fire than is usually provided in the case of boxed timber.

PHYSICAL EFFECTS OF DIFFERENT METHODS OF TURPENTINING IN THE PAST UPON THE LIFE OF THE FOREST.

ANCIENT BOX SYSTEM.

Timber worked for naval stores under the old box system is more subject (1) to fire, from which may result death, or such injury of vitality that little or no product is yielded afterwards. From the severity of the box cutting large areas may be thrown by wind and be wholly lost; (2) under this system the forest is rendered unproductive of naval stores practically after the fourth year. Three to four years more of production may be added by cutting boxes on unused sides of the trunks ("back boxing"). The more enlightened operators who own their forests, and therefore value them, and expect to utilize the lumber after the first four years' use, for turpentining, refrain from "back boxing" to avoid the certainty of total or very great loss likely to follow from windstorms, which, as already shown, such over-boxed timber is too weak to withstand.

ALL YOUNG, AS WELL AS OLD, TREES ARE TURPENTINED.

In the earlier great abundance of naval stores producing pine timber only large trees were boxed. The young pole trees were left to grow. "Worked-out" timber was then quickly abandoned for new crops of "round" timber everywhere abundant.

The enormously depleted supply of round timber of to-day results in the boxing of practically every tree the land carries, down to 4 or 5 inches in diameter. This, too, frequently includes every tree. Profitable returns can not be expected from timber less than 10 inches in diameter. No young, unimpaired trees remain to form the future forest. The controlling purpose of this shortsighted policy is to strip the land as completely as possible, because in the life of the present operator another crop of naval stores is not expected. Young trees so severely boxed can not recover sufficiently to grow into thrifty, sound timber; they usually die. Possibility of profitable naval stores production in all sections so treated is either wiped out or will be within half a decade.

NEW CUP AND GUTTER SYSTEM.[a]

Timber worked for naval stores under the cup and gutter system, more conservative than the old box method, is—

1. Least subject to destructive fire, even when the usual annual "raking" is omitted. There are no deep boxes containing greater or less quantities of highly inflammable resin close to the ground, which, once fired, makes possible a burrowing fire at the base of the trees.

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[a] The writer desires to make clear that the discussion here of the superiority of the cup and gutter system over the box method is not a criticism of other systems of turpentining which employ cups. Investigation of the cup and gutter system was begun some eight years ago as a means of abolishing the

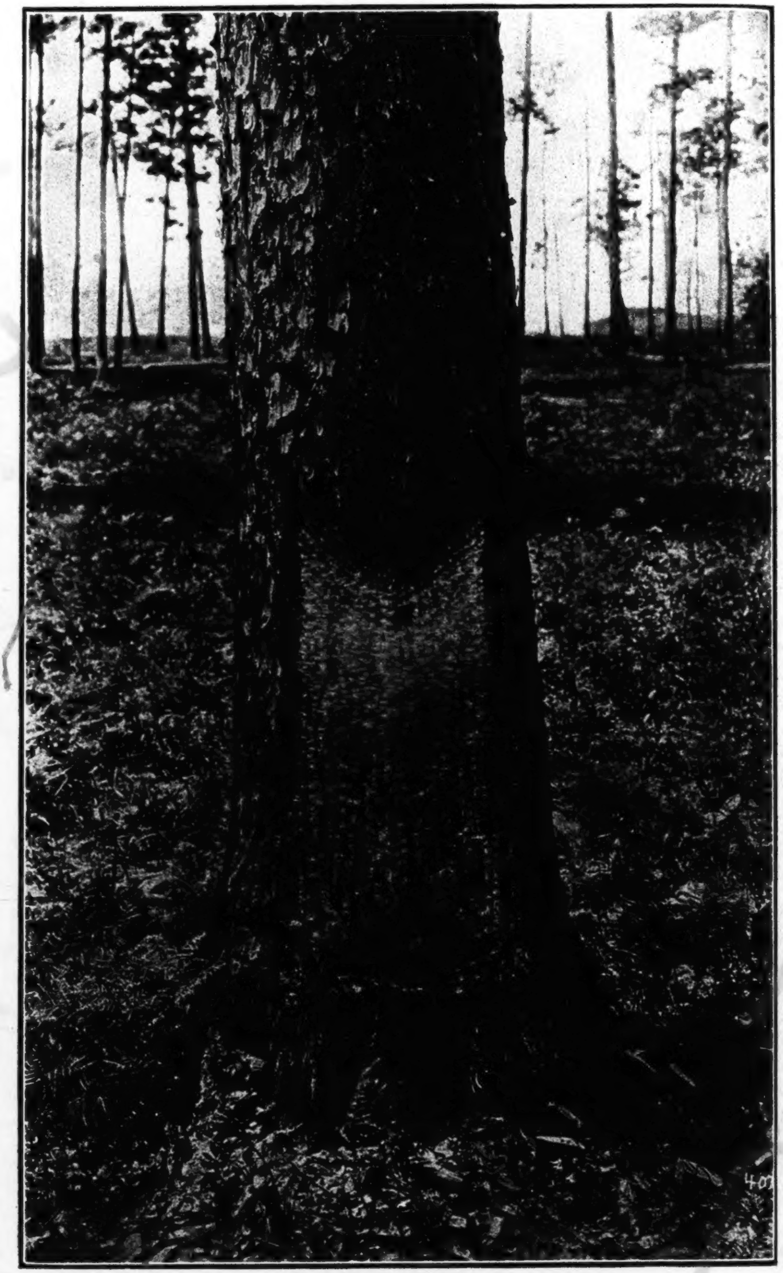

FIG. 4.—FACE OF SECOND YEAR BOXED TREE. NEAR OCILLA, GA.

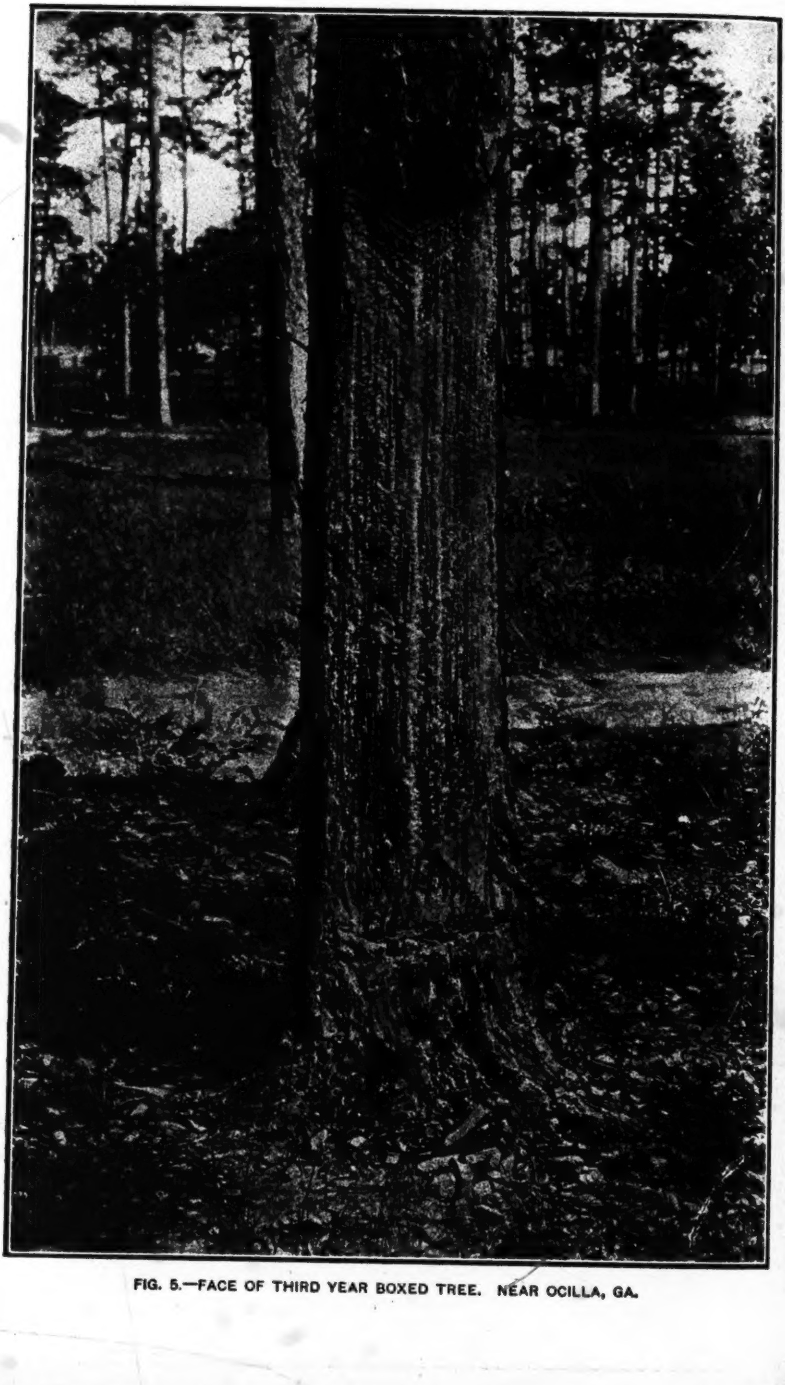

FIG. 5.—FACE OF THIRD YEAR BOXED TREE. NEAR OCILLA, GA.

2. The trees are not weakened by a deeply cut box, and hence not liable to be windthrown. With only a minimum injury from chipping, trees worked under the cup and gutter system maintain vigorous vitality during the period of production, while afterwards the trees continue to grow thriftily. Even very small trees so worked survive the strain and continue to grow rapidly afterwards.

On the whole pine forests "worked out" in part or completely under the cup and gutter system have undergone much less injury as regards their growing vitality than would have been the case had they been boxed. Ripe timber is in condition to be lumbered without loss by storm, while the younger trees are still in thrifty condition.

LOSS OF POSSIBLE PRODUCT UNDER ANCIENT BOX SYSTEM.

Naval stores production under the ancient system of boxing the trees is carried on at a loss of from 20 to 30 per cent of the possible total product. Moreover, the highest grade of rosin is produced by this method only during the first season.

The loss of product (extending over the four or five years of exploitation) is due (1) to undue evaporation (avoidable under a conservative method) of turpentine by long exposure of the crude resin, which must run farther and farther each season over the chipped face of the trees before reaching the box (see figs. 4 and 5). At the end of the first season the distance traversed by the resin is approximately 15 inches; second season, 30 inches; third season, 45 inches; fourth season, 60 inches. Evaporation is relatively greater each succeeding season, as the resin is exposed to the air for a longer time.

The loss in the quality of the product is measurable only in the grades of commercial rosin produced. Resin gathered from first year or "virgin" boxes yields the highest (whitest) grade of rosin. That gathered from second, third, and fourth year boxes yields lower and lower (darker colored) grades of rosin, which sell for lesser prices than the highest grade.

INCREASED PRODUCTION UNDER NEW CUP AND GUTTER SYSTEM.

The total loss of from 20 to 30 per cent of turpentine under the ancient box system of turpentining is saved by use of the new cup and gutter system. This saving is made possible—

1. By preventing the long exposure to the air of the dripping resin, which each succeeding season traverses a distance of not more than 15 inches of the

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destructive box. The superiority of a cup system over the box was demonstrated by the Forest Service with the publication of Bulletin 40 and Circular 34. Since then other cup systems have been devised. The writer has no knowledge, based on actual use, regarding the merits of these systems compared with the cup and gutter system. The important principle of greater conservation of the forest's life and of the turpentine product was clearly demonstrated by the service's use of this particular cup system, and need not be redemonstrated for other cup systems, for the reason that in detailed working, cost of equipment, etc., there does not appear, in the writer's judgment, to be any features of the newer inventions which could increase the advantages, already brought out, of a cup system compared with the box method. For this reason the writer considers the comparative merits of cups and boxes sufficiently settled in so far as the principles of conservation are concerned. Of more immediate importance, as a source of greater conservation for the turpentine industry, has seemed to the writer to be the question of the shallowest chipping possible consistent with the greatest yield of resin.

tree's chipped face before entering a circular, impervious clay or metal receptacle. This is accomplished by moving the metal gutters (which catch and direct the resin into the receptacle) up to the cup at the end of every season.

Measurable gains in favor of this system also are the facts that less evaporation of spirits occurs from the smaller surface of resin exposed in the circular cup than from the larger surface of resin exposed in the box, and greater economy of crude resin is possible also in gathering ("dipping") resin from circular, smooth cups than from the rough boxes. Much resin is wasted in dipping from boxes, as well as in being imperfectly directed and caught in the boxes, while no resin is wasted when it is being directed into the cups or in collecting from cups. Practically all of the resin yielded by cupped trees is caught.

2. The loss in the quality of rosin made from resin of boxed trees is prevented in the case of cupped trees by causing the resin to run uniformly each season only a short distance into the receptacle. A longer exposure of the resin is found to account for the dark color of inferior rosins obtained from two, three, and four year boxed trees.

POSSIBLE CONSERVATION OF REMAINING FOREST BY USE OF IMPROVED METHOD OF NAVAL STORES PRODUCTION.

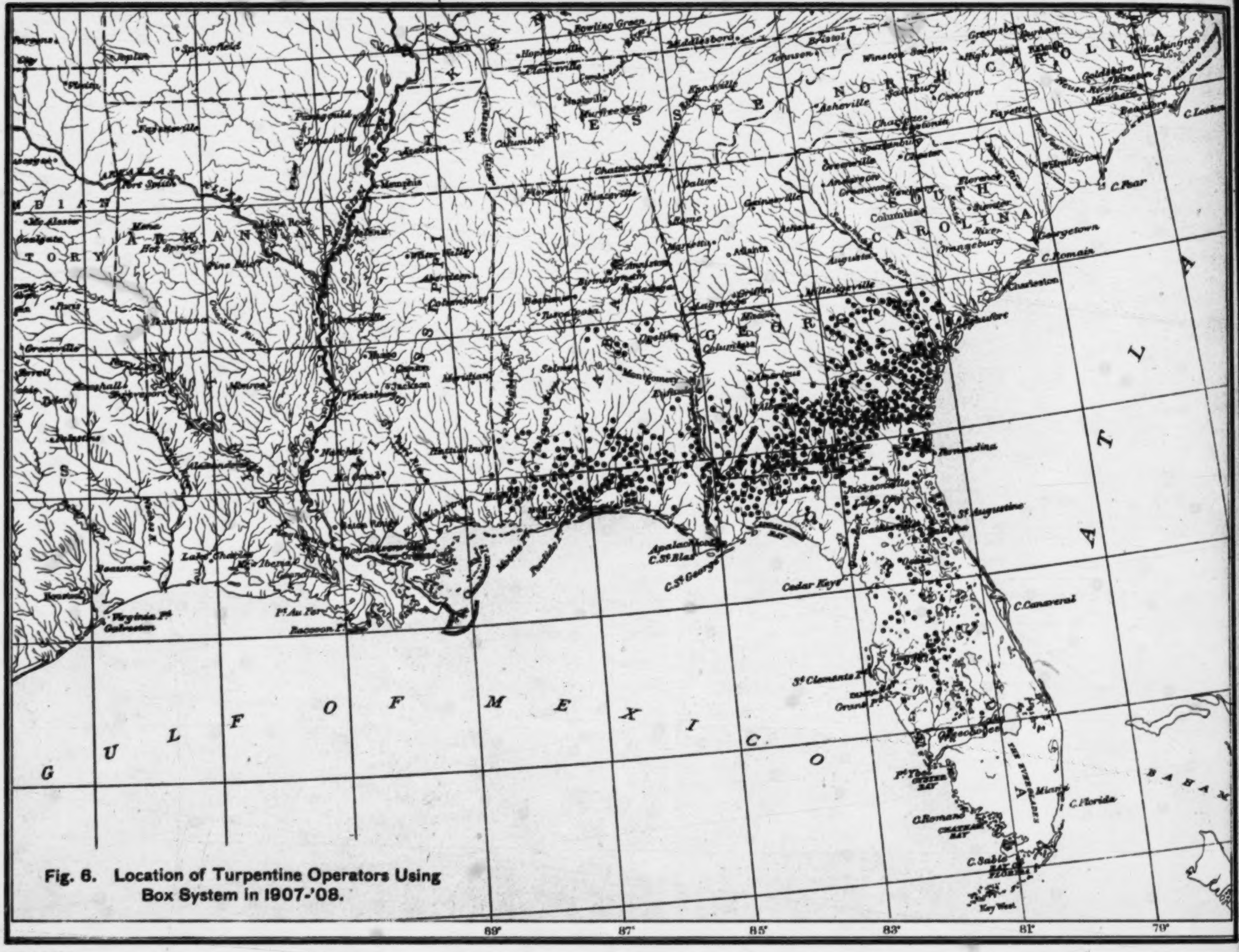
HOW LONG NAVAL STORES PRODUCTION WILL CONTINUE UNDER PRESENT METHODS.

It is estimated that naval-stores production would continue, under present methods of exploitation, for twenty-five to thirty years. At that time it is certain that from an industry of the first importance to the South it would sink to an inferior position. This conclusion may be safely founded upon the history of the production in Virginia, North Carolina, and South Carolina (now practically worked out). These States, once heavy producers, have retired from the field of important production, not to enter it again under present methods of exploitation. The States now yielding naval stores are necessarily meeting a much more intensive demand both for naval stores and for lumber (which must, in succession, come from the same forest) than forests of the exhausted States could possibly have been subjected to. It is even probable that present-day methods of exploiting naval-stores forests would bring the end in less than twenty-five years.

ATTITUDE OF NAVAL-STORES OPERATORS TOWARD PERMANENCY OF INDUSTRY.

Present-day naval-stores operators appear generally content to believe that continuance of their industry is coincident with the endurance of southern pine forests. The conviction is fixed that a given forest can be worked only four years, when new (round) timber must be sought for a continuance of operations. The end of this production is clearly conceived to be coincident with that of the virgin forest.

The idea of placing this industry upon a stable, permanent foundation by adopting a more conservative method of operating appears to have been but little thought of. To this end, the idea of adopting the cup and gutter system, a method of exploitation more conservative of the forest's life, in order that operations might not, as under the ancient method, destroy the trees, proved to be a most difficult undertaking for the Forest Service to propagate among operators, so fixed had become the belief that no method except the ancient one could be profitably employed. The accomplishment by the Forest


G U L F   O F   M E X I C O
GEORGIA
SOUTH CAROLINA
NORTH CAROLINA
TENNESSEE
ARKANSAS
ATLANTIC
Memphis
Little Rock
Montgomery
Atlanta
Augusta
Milledgeville
Charleston
Georgetown
Wilmington
C. Fear
C. Romain
Fernandina
Jacksonville
St Augustine
Apalachicola
C. St Blas
C. St George
Cedar Keys
C. Canaveral
St Clements Pt
Miami
C. Florida
C. Romano
C. Sable
Key West
Galveston
Beaumont
Houston
Natchez
Vicksburg
Jackson
Meridian
Hattiesburg
Knoxville
Chattanooga
Asheville
Charlotte
Greensboro
Durham
Raleigh
Winston Salem
Columbia
Orangeburg
Beaufort
89°
87°
85°
83°
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79°

Fig. 6. Location of Turpentine Operators Using Box System in 1907-'08.

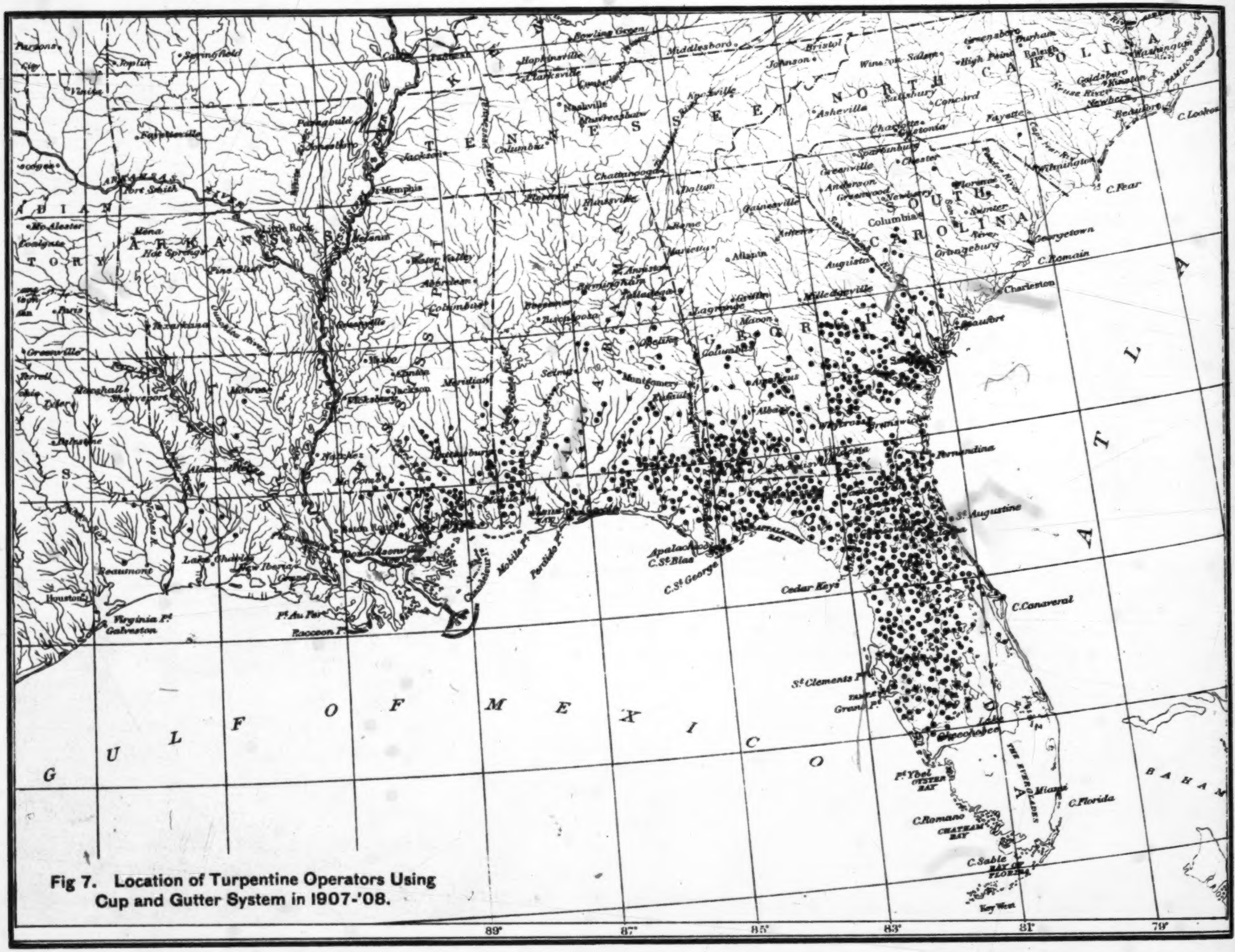

Fig 7. Location of Turpentine Operators Using Cup and Gutter System in 1907-'08.

TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ARKANSAS
GULF OF MEXICO
ATLANTIC
Parsons
Joplin
Springfield
Vinita
Fayetteville
Fort Smith
Little Rock
Hot Springs
Pine Bluff
Texarkana
Shreveport
Marshall
Monroe
Vicksburg
Jackson
Meridian
Natchez
McComb
Hattiesburg
Alexandria
Lake Charles
New Iberia
Baton Rouge
New Orleans
Beaumont
Houston
Virginia Pt.
Galveston
Pt. Au Fer
Raccoon Pt.
Memphis
Helena
Greenville
Columbus
Aberdeen
Water Valley
Tuscaloosa
Birmingham
Anniston
Talladega
Selma
Montgomery
Mobile Pt.
Perdido
Pensacola
Apalachicola
C. St. Blas
C. St. George
Cedar Keys
St. Clements Pt.
Tampa
Pt. Ybel
Oyster Bay
C. Romano
Chatham Bay
C. Sable
Bay of Florida
Key West
Miami
C. Florida
The Everglades
Okeechobee
C. Canaveral
St. Augustine
Fernandina
Brunswick
Waycross
Albany
Americus
Macon
Columbus
Lagrange
Griffin
Atlanta
Marietta
Rome
Dalton
Gainesville
Athens
Augusta
Milledgeville
Beaufort
Charleston
Orangeburg
Columbia
Georgetown
C. Romain
Sumter
Florence
Newberry
Greenwood
Anderson
Greenville
Spartanburg
Chester
Charlotte
Gastonia
Wilmington
C. Fear
Fayette
Concord
Salisbury
Asheville
Knoxville
Chattanooga
Huntsville
Florence
Nashville
Murfreesboro
Columbia
Jackson
Clarksville
Hopkinsville
Bowling Green
Middlesboro
Bristol
Johnson
Winston-Salem
High Point
Greensboro
Durham
Raleigh
Goldsboro
Kinston
Newbern
Beaufort
Washington
C. Lookout
Pamlico Sound
Neuse River
Cape Fear R.
89°
87°
85°
83°
81°
79°

Service, through four years of incontestable demonstrative field results, of showing that the cup and gutter system should replace the old box method, was achieved against the deepest sort of prejudice and disinclination among otherwise intelligent operators to accept a new system for the one inherited so long ago. The argument had to be abandoned that, if the new system insured as great a return in naval stores as the old destructive method, it would be to the interest of timber-owning operators to apply this new, conservative method because, not necessitating the cutting of a deep basal box, it injures the trees far less than the ancient system. The idea alone of conserving the life of the forest, of leaving it in as thrifty a condition as possible after naval-stores production, found little or no support. Had it not been possible for the Service to show by actual figures of yield that the new system gives a return of from $1,500 to $1,600 per "crop" (10,000 trees) in place of about $1,000, the old method would still be in universal use, where now some 30,000,000 cups are used. (See figs. 6 and 7.)

Even with this overwhelming proof of what the new conservative method offers in money returns alone, there are many intelligent operators who will not abandon the old system. There is probably not another example to be found in the development of any industry in this country where regional prejudices is so strong against a change of old customs. It is believed, however, that ultimately the idea of maintaining highest conservation in naval-stores production and of placing this industry on a permanent basis can be made to prevail.

Economic conditions are such in the United States that the extremely conservative system of production prevailing in European countries can not be adopted here. The returns accepted there from a naval-stores forest are too small to attract the average American operator. The rate of production and the profit are comparatively much larger here and must needs continue to be in order to satisfy our social conditions. Our past lavish waste in producing naval stores must be reduced to the strictest economy in method of exploitation and in perpetuating, by full use, the life of naval stores producing forests.

WHAT IS ACCOMPLISHED IN CONSERVATIVE NAVAL STORES PRODUCTION AND IN LENGTHENING THE LIFE OF THE FOREST BY A NEW METHOD.

The Forest Service has established by incontestable experiments that the cup and gutter system of deriving naval stores—

1. Yields 30 per cent more product than the ancient method.
2. Does not so weaken the trees physically that they are in danger of being wind thrown.
3. Leaves the timber in thriftier condition because it has not been severely injured by box cutting.

The advantages accruing directly to timber-owning operators are much greater money returns (approximately 50 per cent more than from the old system), and insurance of the timber against destruction by storm before it can be lumbered. The fact that boxing leaves the timber in imminent danger of total destruction by storm has dissuaded not a few pine-timber owners from turpentining their forests at all. Such loss of profit to those people for want of a safe system of exploitation can now be obviated by adopting, if not the system shown to be most conservative, the cup and gutter system even with the old method of deep chipping, in place of the destructive box method.

WHAT MAY BE EXPECTED FROM A STILL MORE IMPROVED METHOD OF PRODUCING NAVAL STORES.

A still more conservative method has been discovered by the Forest Service, and its absolute practicability has been thoroughly established by experiments during the last three years on some 80,000 trees.

By this method it is calculated that—

1. A crop of trees may be worked continuously for 15 to 20 years, instead, as at present, of 4 years. At the end of this period the same trees may be worked for another equal term of years, provided the utmost naval-stores capacity of these trees needs to be made use of before lumbering.
2. From 22 to 25 per cent of turpentine (the naval-stores product of greatest value) is obtained in place of from 19 to 20 per cent yielded from present (old and new) methods.
3. The vitality of the trees worked is conserved in the very greatest degree, because the injury from chipping or tapping is reduced to a minimum. Little injury to the trees is a factor in the greater production of turpentine, because the trees being more vigorous, yield a continuously strong flow of crude resin. The greater injury of the trees worked under the older systems weakens their vigor and causes them to yield resin less and less copiously each succeeding year.

This system consists in the use of clay receptacles and metal gutters for collecting the crude resin, and the application of uniformly shallow chipping in place of the generally practiced deep chipping.

DISCUSSION.

The three exceedingly important points of economy in this method are: (1) Greatly increased term of operation; (2) greatly increased product; and, (3) the fullest possible conservation of the growth energy or vitality of the trees.

The high productiveness made possible and the practically indefinitely prolonged operation in one location are the principal factors sought in establishing permanent naval-stores production. Both factors are commercially attractive to the individual operator who must realize profit in his own lifetime. A permanent industry and the greatest conservation of the forest under naval-stores production are also directly effected.

DETAILS OF MOST IMPROVED METHOD.

It is possible now to prolong the working period in the forest without change of base, because the new method requires the cutting away each year of only from 3½ to 4 inches in height of the usable trunk, while in the older systems of chipping or tapping from 15 to 16 inches in height were cut away each season.

It has long been believed by operators that severely deep chipping each week must be resorted to in order to stimulate the fullest flow of crude resin. The Service's experiments have proven, however, that extremely shallow chipping gives the greatest possible flow of crude resin, while the crude resin from such shallow chipping yields a larger percentage (approximately 5) of turpentine than does the resin from deeply chipped trees.

DEGREE OF SHALLOW CHIPPING ACCOMPLISHED BY USE OF THE OLD "HACK."

By special training chippers can put very much shallower "streaks" on the trees each week than are commonly cut with the ordinary "turpentine hack." The best possible saving with this tool is something over one year in three, or nearly two years in four, thus extending the usual working period of a forest from four years to six years. Even this shallow chipping was, however, found to be unnecessarily severe. But the limit of perfection is soon reached for this ancient tool because, as in the use of the ordinary chopping ax, control of the cut is dependent entirely upon the personal skill of the chipper, and this can not be made as perfect as is necessary for the fullest economy in chipping.

HOW THE SHALLOWEST CHIPPING IS ACCOMPLISHED BY USE OF A NEWLY INVENTED HACK.

A new turpentine hack has been invented, through directions of Forest Service experts, which affords perfect control of the depth and width of the "streak" cut. The skill of the chipper is not, as in the use of the old hack, a factor in cutting a shallow streak with this tool. A uniformly shallow chip can be taken off, thus making it possible to treat all trees alike and to cut only enough to stimulate each week a full flow of crude resin. Limited experiments indicate that a full yield of crude resin may be obtained by chipping the trees only from three-eighths to one-half of an inch in depth, and in height only from one-eighth to three-sixteenths of an inch. The common practice is to cut a streak from 1 inch to 1½ inches deep and from one-fourth to one-half of an inch high each week.

An important feature of this tool is that, when it is fully perfected, it can be applied to the tree in practically the same manner as the old hack. This will make it unnecessary for chippers to acquire the use of a new instrument—a nearly impossible accomplishment because of deep prejudice among turpentine laborers.

This tool is not in use by turpentine operators, for the reason that, while the working principle of the invention is established, considerable experimentation is required to perfect the detail working of the tool. Moreover, the Service has not yet published the practical results of its study of shallow chipping. The publication and distribution of these results is to take place shortly. With full knowledge then of the special advantages offered by the use of a shallow cutting hack it is moderately certain that the Service's new and highly conservative method of turpentining will be generally accepted.

FURTHER CONSERVATION OF PRODUCT POSSIBLE BY NEW SYSTEM OF GATHERING CRUDE RESIN.

Studies by the Forest Service indicate that from 5 to 6 per cent more turpentine is yielded by crude resin gathered every two weeks than from resin gathered once in four weeks. When gathered once a month, the long exposure to the air results in an appreciable loss of turpentine by evaporation. The added expense of more frequent gathering is trivial compared with the percentage of profit gained by the increased yield of turpentine. These studies, only indicative now of probable results, must be carried further before a positive statement of the possible gain can be made.

INCREASED PRODUCT BY CONSISTENT USE OF ALL NAVAL STORES PRODUCING PINES NOT NOW EMPLOYED.

SOUTHERN PINES.

At present only two pines, the longleaf and slash pines, produce this country's naval stores. The Service's study during the past three years of the distinguishing characters of the resins of native pines shows that three more forest-forming pines of the South (loblolly, shortleaf, and Virginia pines) yield naval stores in quantities equal to those of the longleaf and slash pines. Two of these untried species, generally held by operators to be nonproducing, form large forests in the South Atlantic and Gulf States as far west as eastern Texas and northward into Missouri. Their use for this purpose would augment the country's present resources very considerably, and would, in addition, extend the industry into States never before yielding naval stores, and serve also to restore in some measure the industry to States which have ceased producing. It is impossible now to determine what percentage of increase this addition to the resources will add. With the very probable return, by encouraged natural propagation, of these untried pines to areas from which they have been lumbered—unquestionably a wise policy—a still greater naval-stores resource will certainly be added in the future.

WESTERN PINES.

Similar studies by the Forest Service have recently determined that the forest-forming western yellow pine yields naval stores in quality and quantity comparable with the standard longleaf and slash pines of the South. The addition of this tree, which forms extensive forests both in the Rocky Mountain and Pacific Slope States, as a producer will give to western United States a new industry, the value of which can not be adequately estimated. Development of it will require demonstrations by the Forest Service of a special method of tapping the trees and the amount of commercial product obtainable. This is a work distinctly for the Forest Service to undertake on a sufficiently large scale to show what may be expected in that region, which in topography and in the character of its resin-producing pine is so different from the South that the system of turpentining now practiced in the latter region will require special modifications.

FUTURE STABILITY OF NAVAL-STORES INDUSTRY.

Future stability of the naval-stores industry in this country depends upon three factors:

1. Complete application in all naval stores producing forests of the most conservative system of exploitation.

2. Use throughout the country of all naval stores producing pines.
3. Systematic working of forests for naval stores in coordination with lumbering operations.
4. Effective fire protection.

COMPLETE APPLICATION OF THE MOST CONSERVATIVE SYSTEM OF EXPLOITATION.

Experience of the last half century has shown clearly, in the case of Virginia, the Carolinas, and Georgia, that so wasteful and severely injurious a system of turpentining as the ancient box method results in exhausting the producing forest at such a rapid rate and in such a short period as to preclude all possibility of permanent naval-stores production under that system in any given region. Under such a short-sighted policy and system continuance of the industry is clearly a question, not of established permanent production throughout the regularly maintained forest of the country, as in the case of wheat and other staple productions which become fixed resources of certain sections of the country, but of how long the country as a whole will continue to produce naval stores. Continuance of production is then dependent chiefly upon how long the suitable species of virgin timber of the country will last.

The center of greatest production, beginning at the northeast part of the southern pine forest, has gradually proceeded southward in the Atlantic region to the working limit of this turpentine pine belt. The center of greatest production has, to be sure, gone southward with the development of the southern country, but its progression has been like that of a great and consuming forest fire. A stable industry—a resource—naval-stores production, has not been left along the line of its march. Like the forest fire, it has been transient, flourishing only so long as round virgin timber remained to feed the flames of its turpentine "stills." The timber exhausted—worked out—new stills sprang up farther and farther southward in the great pine belt. New centers of business activity were formed and those in the rear died out. The forest that once gave support is gone or depleted beyond profit for the turpentine operator using the old system. Just as the lumbermen of the Great Lakes pine belt have been forced to go to the untouched forests of the Northwest, so the naval-stores producer of the South has gone farther and farther southward. The Georgia operator is now in Florida, the center of greatest supply, where he is producing heavily. Soon he will be obliged to look westward to the end of the Gulf pine forest.

Production by so wasteful a method that permanency of the industry is impossible, and the end of production can be clearly seen, is inconsistent with the possible permanent development of one of the South's greatest resources.

Use of the most conservative system of turpentining is imperative, therefore, for two reasons:

1. To build up permanent local production wherever a wise forest policy for that section makes it advisable to maintain continuously naval-stores and timber-producing forest.

2. In order to prevent degradation, through the present too rapid exhaustion of existing old forest, of a first-rank industry to a position of unimportance.

Approximately 20 per cent of the sound timber of the South is still unworked for this purpose. Application to this timber of the latest improved system of turpentining will permit it to be worked for twenty-five to thirty years before lumbering, and will go far toward staying the present rapid and premature exhaustion of a great naval-stores resource. Continued local production, which is greatly needed for the permanent upbuilding of otherwise resourceless sections, will also be encouraged and eventually established.

USE OF ALL NAVAL STORES PRODUCING PINES.

Just as in the sphere of agriculture, there exists, for the sake of the highest economy in production for every region, the necessity of growing as many different kinds of useful crops as possible, so in the field of naval-stores production it is imperative that all producing pines and other conifers be fully exploited for this product. In bringing this about, the most important principle of industrial economy would be fulfilled—the utmost development and utilization of existing resources.

SYSTEMATIC WORKING OF NAVAL-STORES FORESTS IN COORDINATION WITH SUBSEQUENT LUMBER OPERATIONS.

Coordination of naval-stores operations with the lumber operations which follow is looked to but little at present in the exploitation of pine-timber forests capable of yielding two such valuable products. That by careful attention to the proper sequence of rotation of these industries in a given forest the fullest economy in productiveness can be practiced is not to be questioned.

The presence of apparently unlimited timber supplies for pursuing both industries independently has been sufficient justification in the past. Now, however, with greatly decreased supplies of naval-stores forests and enormously increased annual demand for the products of these forests, there is imminent danger of unwarranted waste of the forests' productive energy by inattention to the proper coordination of turpentining and lumbering operations.

A few owners of naval-stores forests are now combining in one continuous operation the production: First, of naval stores; and second, of lumber—the operation intended to strip the land, to make full and final use of the stand. Realization of fuller value from their ownings is the incentive for combining the two industries, just as the great steel manufacturers have come to realize fuller profits by owning and mining the coal they use in making steel. The principle aimed at, but not yet effected, is proper coordination in turpentining and lumbering operations—a combination of effort which is highly essential for practicing the utmost economy and deriving the fullest returns from a naval-stores forest.

Under the ancient method of turpentining much timber has failed of proper utilization for lumber after being worked out for turpentine, because lumbering was not planned to follow at the close of the turpentine work. At the present time many lumbering operations are crowding out, on too short periods of rotation, the production of naval stores or are neglecting it entirely. Both are unjustified in this period of greatest need for utilizing the fullest productiveness of forests. No data are available now to show comparatively the ratios of profit in lumbering naval-stores forests and in working them for this industry to the costs of property and of carrying on the two operations. It is believed, however, that relatively much greater returns are realizable from naval-stores operations. Certainly in the fullest economy of use the turpentine forest should be made to produce its fullest returns before ripe portions of the stand are lumbered. This, when properly coordinated with the subsequent lumber operations, will make greatly for the permanence of the industry.

With the accomplishment now of a highly conservative, and at the same time profitable, method of turpentining, all lumbering and naval-stores operations should, for the permanence of both the industries themselves and for the owner's profits, be so carefully coordinated that the lumber interests take up and use the turpentined timber only after it has been made to give its fullest returns of naval stores.

Future studies of the Forest Service are to determine whether or not its extremely conservative method of shallow chipping for turpentine may not be applied to half-grown or to large immature timber without actually checking its profitable annual increment of growth. Should it be possible in this way to work a comparatively young forest for naval stores up to maturity, the long period of naval-stores production sought now during mature life of the forest, will not hold the mature timber out of lumber operations so long beyond the point of mature growth.

EFFECTIVE FIRE PROTECTION.

A word only needs to be said regarding the relation which effective fire protection bears to the permanency of the naval stores industry. Ground fires are the naval-stores operators' greatest and most dreaded enemy. His equipment and "crops" of turpentined trees may be ruined by severe fires. At considerable expense the inflammable trees are protected at the end of every season by raking in a small circle about each tree. Even this does not insure complete protection, for many "crops" are then burned.

The turpentine operator is, therefore, in position to welcome effective state or national fire protective measures. He has come, however, through the apparently impossible enforcement of existing forest-fire laws, to depend upon the protection he himself provides. He prepares, as best he can, to meet the annual ground fires which "irresponsibles" set out. When it can be safely done he burns the grass himself to prevent others from doing it less carefully.

The naval-stores operator would not be inonvenienced if the forest were unburned. Owners of cattle ranged at large in Southern pine forests are charged locally with burning the forests every winter to improve (?) the grass (now only tough sedges which afford little nutrition, as evidenced by the extremely small size of pine-forest cattle).

CONSERVATIVE LOGGING.

By **Earle N. Clapp,**
Chief of Management, Forest Service.

MANNER IN WHICH MATERIALS ARE USUALLY WASTED.

To one who is familiar with woods work in the United States it is a matter of certain knowledge that in all cases the fullest possible use is not made of the timber cut, and that little thought is given to the question of future supply from areas which are being cut over.

The logging methods which have been used are in all cases the result of conditions. Very naturally a lumberman wishes to operate at a profit, and often he considers the timber supply inexhaustible. In some other cases carelessness and wasteful methods are due to the desire of the lumberman or foreman to avoid conflict with laborers, and very frequently prejudice concerning utilization is responsible for certain classes of waste. The great factors are, however, stumpage and market prices. It is obvious that the percentage of timber wasted in different regions, or even in the same region, and in logging different species, or even the same species, will vary greatly.

Utilization in European countries is much more complete than in the United States, and comparisons when made usually reflect upon operations in the United States. When it is considered, however, that stumpage prices for various kinds of wood in Europe are to-day from two to ten times as great as for the same class of material in the United States, the reason for closer utilization in Europe is obvious. It is decidedly encouraging, however, that utilization in the United States at the present time in some cases is nearly as close as market conditions and stumpage rates will warrant, and such cases are more numerous than ever before.

The reasons for the closer utilization of to-day are clear: Much of the available timber has been cut, and many of the better species, as, for example, eastern white pine, are nearly exhausted, and market prices for the manufactured product are such that the lumberman can well afford to cut low stumps, utilize timber well into the tops, utilize dead timber, and to remove from the woods much more of the merchantable material than formerly.

A casual examination of a cut-over tract gives very little idea of the amount of merchantable material which has actually been wasted. It requires a thorough knowledge of market conditions and a series of actual measurements to determine accurately the percentage of unnecessary waste in any operation.

MATERIAL LEFT IN THE WOODS.

The most wasteful method of logging is that in which all of the material cut is left in the woods. Cases of this kind have in the past been comparatively frequent, and even at the present time one occasionally sees lumber operations in which little or none of the material cut has been removed. It is not infrequent to find logging operations in which, because of weather conditions, only a partial removal of the timber is possible, and still more frequently it is impossible to remove material cut soon enough to prevent deterioration; for instance, in basswood operations in the North and Northeast, if the logs are left on the ground for a year discoloration of the sapwood follows at least. This reduces greatly the price which may be obtained for the manufactured product by diminishing the amount of lumber of the better grades. This, of course, in cases in which logging is delayed only one year, does not mean an actual loss of material, but loss through failure to utilize to the best possible advantage the material cut. While this kind of loss is exceedingly common, it is difficult to estimate its exact amount.

Heavy snowstorms are frequently responsible for the leaving of large numbers of logs in the woods. Whole skidways are covered and often lost track of, and in many cases it is impossible to return the following spring for logs and skidways which have been left. The fact that the loss in this manner differs frequently in different operations in the same region and under the same conditions shows that in many cases it is more or less due to carelessness. The leaving of lodged trees, while it seems infrequent in the average logging operations, is in reality responsible for a large loss, considering the cut of the whole United States.

In the early days immense tracts of lands in the eastern hardwood belt were cleared for agricultural purposes and the timber destroyed because no markets were available. While this practice is almost a thing of the past, the destruction of all the timber cut from agricultural lands sometimes occurs even to-day. More frequently sawmill men purchase the timber from such tracts at a specified rate per acre and utilize as much of the saw timber at they care for. All the remaining timber is cut and burned, and this in many cases amounts to a considerable waste. There is little excuse for this form of waste under present conditions, since hardwood stumpage for saw timber is now rarely selling for less than $5 per thousand feet b. m., and cordwood stumpage almost universally for $1 per cord.

BAD MANAGEMENT.

Badly managed logging operations are responsible for immense losses, which may include practically all of the classes of waste hereafter discussed. Very frequently the best means of transportation are not used. It is estimated, for instance, that if basswood logs are driven instead of being hauled to the mill by railroad that the loss in the manufactured product, under the most favorable conditions, is at least $2 per thousand. Because of poor management, removal of timber is frequently delayed unnecessarily, so that deterioration to a greater or less extent follows.

INFLUENCE OF OWNERSHIP.

Another factor which under very similar conditions influences greatly the percentage of waste in logging operations is whether the timber is cut by the owner of the land, the owner of the stumpage only, or under stumpage contracts. Frequently the actual sale of the land with the stumpage may mean careful logging and little unnecessary waste, while the sale of only the stumpage based upon a scale after cutting, or cutting under a stumpage contract, will be followed by very wasteful methods in order that the operator may assure himself of the maximum profits.

LEAVING OF INFERIOR SPECIES.

It has been the exception rather than the rule in the operations of the past for lumbermen to remove more than one or two of the most valuable species of timber from an area in one cutting. Take, for example, the history of logging operations in the Northeast. The first cut removed the white pine and a very few of the largest and best spruce; the second operation followed several years later, removing only the large spruce which was left; after another interval the third operation took out all the softwoods, regardless of size, which were suitable for pulp. In many districts the fourth logging operation is now in progress, and includes the hardwoods left from previous cuttings.

Forest Service Circular No. 118, "Second growth in the Southern Appalachians," gives another instance of first logging the more valuable species from a tract and later returning for other species. It states that many tracts in the Southern Appalachians have been logged at least three times during the last ten years. In the first logging only the poplar and white oak saw timber were taken; the next operation removed the oak timber suitable for staves, and the final logging operation removed the smaller and rougher saw and tie timber of all species. Poorer species still remain on the ground.

Considerable parts of the forests of the United States, particularly of the West, are made up of only two or three species. It is customary in such forests, where there is a great difference in the relative value, to cut only the better species, with perhaps a few of the very best trees of the inferior kind. The species left is so inferior and the stand so scattering that until market conditions and requirements change greatly it will be absolutely impossible to return. The Douglas fir and hemlock stands of the Pacific coast, and lodgepole pine and balsam stands of the Rocky Mountains are familiar examples. In the Douglas-fir forests on the coast it is not uncommon for lumbermen to leave from five to twenty-five thousand feet b. m. of merchantable hemlock to the acre, and this in most cases can not afterwards be logged.

Examples of a similar kind can be given for logging operations in other parts of the United States. While it is realized that logging of this kind is usually the result of actual conditions which would have prevented the removal at a profit of all species at the same time, and that the lumberman was therefore forced to conduct his operations as he did, it can not be denied that the economic waste through such methods is enormous. Usually the intervals between logging operations are so long that logging roads have to be reconstructed. It is not customary to follow the same course, and this means that a large amount of timber is cut for building roads. When the best species and the largest trees are removed many of the smaller trees and trees of inferior species are broken, and many more are cut to provide space for skidways and skid roads. The slash which is usually left burns in many cases, and causes great destruction in the timber. One of the greatest losses, and one often least considered, is that of the change in the composition of the forest. If the seed trees of the best species are removed it necessarily follows that the resulting reproduction must be of the inferior kinds.

The results in national forest sales show conclusively that inferior species may be taken in practically all logging operations. In a number of sales on the Manti Forest, in Utah, the total cut is made up of 91 per cent of the valuable Engelmann spruce and 9 per cent of the comparatively valueless white fir. On the Modoc Forest, in California, 5 per cent of the total cut in a number of sales is made up of white fir and 95 per cent of yellow pine. In a number of the sales on the Sequoia Forest, in California, 78 per cent of the total cut is made up of the valuable sugar and yellow pine, while 22 per cent is made up of the inferior white fir and cedar. Purchasers object in some cases to the inclusion of inferior species in sales, and there is more or less difficulty in marketing the product manufactured from such species. Even when inferior species are included, however, purchasers have finally been able to market the product and to compete successfully in the general market with lumbermen who are cutting from privately owned lands and who do not remove inferior species to any great extent.

LEAVING OF SMALL BODIES OF TIMBER.

It is the experience of nearly all lumbermen that small bodies of timber in comparatively inaccessible places are, as a rule, left when the area is cut over. In many cases such bodies of timber could be removed at a slight profit or without actual loss. If small bodies of timber of this kind were removed it would enable lumbermen to hold other accessible timber, and the rise in stumpage prices at the present time is so rapid that the gain would be considerable in most large operations. Generally, when small bodies of inaccessible timber are left it is impossible to go back after logging is completed and the camps are taken out. Contracts for the sale of timber on the national forests provide against this form of waste and require purchasers to remove such bodies of timber, sometimes even at little or no profit, since such removal means an economic gain to the country as a whole. Such features are, however, provided for by just stumpage rates for the whole sale.

ONLY ONE CLASS OF MATERIAL TAKEN.

Lumbering operations in which only one class of material is removed from the forest are not uncommon. In cases where this material is saw timber the waste may not be excessive, but in other operations in which, for instance, only hewn railroad ties are utilized, much merchantable timber is necessarily left. Of course stumps can be cut low in most species, but the utilization in the tops is not as a rule complete. The greatest loss when ties are cut is perhaps owing to the fact that only trees of certain size, from about 11 to about 17 inches in diameter, can be taken; in other words, the young and thrifty trees of most species are removed from the stand, while the mature and slowly growing trees are left. These mature trees in many cases will be a partial or entire loss before the area in question can be cut over a second time.

Another illustration of great waste, owing to the utilization of only certain products, is in the shake business of the Sierras. Only the sugar-pine trees which split easily can be taken. This means that many trees, even though felled, must be left. Since only the straight grained, clear part of the trees can be taken, all material in the tops must be wasted. Fortunately, however, this form of waste is largely a thing of the past.

LEAVING OF DEFECTIVE AND DEAD TIMBER.

In the usual logging operation a large number of the trees which are only partially merchantable are not removed. For instance, it is found in many of the sales on the national forests that a considerable percentage of the trees in the stands may contain only one merchantable log, and that this log may be cut and removed at a slight profit or without actual loss. The prejudice against the use of dead timber is also responsible for a large percentage of loss in most lumber operations. Contracts in all sales from the national forests provide that the purchaser shall remove merchantable dead timber. In a number of sales in Utah, which include both dead and living timber, 10 per cent of the total cut was dead timber, and for a number of sales in Colorado and southern Wyoming 20 per cent of the total cut was dead timber. This, of course, is an addition to the large amount of dead timber sold in the sales including only dead timber. It is a matter of great interest that in some forests at the present time 40 per cent of all the timber which is being removed is dead. Defective trees which contain one or more merchantable logs and dead timber, if not removed during the first logging operation, are almost certain to be a total loss.

BEST TREES AND SPECIES USED FOR CONSTRUCTION.

Until the past few years it has been the practice in practically all lumber operations to use the best species of trees, and even the best trees, for various construction purposes, such as camps, road making, etc. In almost all cases poorer trees of the better species and trees of inferior species have been available. It is true that in some cases they are not quite as suitable for construction purposes as the better species and trees, but it is certain that the profit in logging operations in the long run is greater by using poor trees for construction purposes. Specific examples of this class of waste are the use of spruce in the Northeast, where balsam and inferior hardwoods are available; the use of good trees in the Southern pine district, where in almost all cases poor specimens are at hand; the use of lodgepole in the

Rocky Mountains, where balsam could well be used; and the use of Douglas fir in the West and Northwest, where hemlock is left on the ground in most logging operations.

USE OF SAW TIMBER FOR FUEL.

The market prices for various classes of material in the United States at the present time, even though they may seem good, are not yet high enough to insure the utilization of all classes of material to the best possible advantage; for instance, during the summer of 1908 one concern in the Northwest bought the best grade of Douglas fir flooring logs and worked them into cord wood. The reason for this was that it was cheaper to buy the clear, straight-grained logs which split easily than to buy at reduced prices and cut up the knotty and inferior logs of lower grades. The practice of utilizing valuable saw timber for cord wood has also been quite common in parts of the Rocky Mountains and in the eastern hardwood district.

USE OF BARK ONLY.

It was formerly the practice, in order to obtain the supply of hemlock bark demanded by the markets, to cut hemlock and utilize the bark, leaving the logs to decay. In northern New York, for instance, for a period of from twenty to forty years the demand for saw timber was so slight and the price paid for hemlock timber in particular so low, averaging about $4, that it was impossible to handle the timber at a profit. For the bark, however, there was a good demand and high prices could be obtained. The amount of waste was obviously enormous when it is considered that the amount of saw timber to a cord of bark is about 1,000 feet. The same practice was carried on in the hemlock regions of southern New York and Pennsylvania.

Under present conditions the bark of chestnut oak is more valuable for its tannin than that of hemlock, and occasionally the practice of cutting chestnut oak and utilizing only the bark is followed in the Appalachians. The total amount of timber wasted in this manner is, however, comparatively small.

HIGH STUMPS.

In practically all old lumber operations stumps were cut excessively high, and while present practices are a great improvement, there is still much unnecessary waste. In old cuttings in the East and in those parts of the West in which the forests are made up of small trees, stumps of 7 or 8 feet are not uncommon in winter cuttings. The reason for this is obvious when the expense of shoveling away the snow from the trees is considered. In summer cuttings, stumps 2½ to 4 feet are not uncommon. For this waste there is no good reason. In the Northwest in practically all of the cuttings of the past spring boards were used, and fir and cedar stumps as a result will average at least 5 feet in height. In this region spring boards have, however, been practically done away with, so that fir stumps are now cut to about 3 feet and cedar to 3½ feet. It is perfectly feasible to reduce the height of fir stumps to about 22 inches and that of cedar, except in the case of defective trees, to about 30 inches. This makes an average loss of at least 6 inches in each tree cut at the present time, which in the aggregate is enormous.

Every lumberman acknowledges that, except for defects, the best quality of lumber in the whole tree is found in the butt log, and therefore, in addition to the actual quantity of timber which is wasted in cutting high stumps, the quality of timber must also be considered.

Some examples of good results now being obtained are of interest. On the national forests, contracts in the Rocky Mountains and Sierra regions provide for cutting stumps to a maximum height of 18 inches, except in special cases, and further provide that the height shall be less if possible. It is reported that in Michigan, in some of the white pine cuttings, stumps are being cut level with the ground. It is commonly known that black-walnut timber is taken down below the ground level by digging around the tree and cutting the roots.

It is decidedly interesting to note the effect of the contract requirements of national forest sales on operations on private lands. One specific instance in western Montana will serve as an illustration. A company logging on its own lands commonly cut yellow pine stumps between 2 and 3 feet. After purchasing timber from the national forests, however, and cutting the stumps 18 inches and lower when possible, the company in question is now requiring the cutting of low stumps on its own lands.

TOPS.

In many logging operations of the past (but rarely at the present time) it was the common practice to take only clear logs and to leave all the knotty logs of the top on the tract. Gradually, however, as market prices have risen, the diameter limit to which trees can be utilized has decreased, until now in the spruce forests of the Northeast private companies utilize spruce and balsam to about 4 inches diameter. In the pine forests of the South logs are commonly taken to a diameter of 10 or 12 inches. In the lodgepole pine and Engelmann spruce forests of the Rocky Mountains cutting on private lands commonly utilizes tops to 8 inches; in the Sierra forests and Douglas fir forests of the Northwest timber on private lands is not commonly cut to a lower diameter than 15 to 20 inches. The contracts in sales from the national forests of the Rocky Mountain regions commonly require purchasers to utilize timber to 6 or 7 inches for saw timber when the logs obtained may be manufactured into merchantable material. The sales from the Sierra and coast forests require purchasers as a rule to take merchantable material to a diameter of 10 inches. Where there is a market for mining material, however, utilization to 8 inches is required. Trees are used for cord wood to 3 inches.

A source of great waste in logging operations throughout the United States has been the fact that tops below saw timber size have not been made use of. In many cases market conditions are wholly responsible for this. In others, it would be possible to utilize tops to a diameter of 2 or 3, or at most 6 inches for some such purpose as cord wood or the manufacture of charcoal.

LOG LENGTHS.

In the usual logging operation on private lands little attention is paid by superintendents and foremen to the question of varying the lengths of logs cut. In almost any logged-over area pieces of merchantable material 8 or 10 feet in length may be found when it is the practice to utilize logs as short as 12 or 14 feet. By properly varying the length of two or more logs all of the timber in most cases might have been saved.

As market prices for lumber increase, foremen and superintendents and owners of stumpage are more and more insisting that log lengths be varied to utilize fully the timber in tops of trees, and that log lengths be varied also in order to obtain the best grade of timber which is cut; for instance, by a proper selection of log lengths bad crooks may be avoided; still another instance is the occurrence of defective places in logs, which may be cut out altogether by a proper selection of lengths, and the amount of merchantable material obtained from the tree as a whole may be often increased by 25 per cent.

The question of cutting logs and lumber into both even and odd lengths has been discussed so frequently that it is unnecessary to go into the subject at this time. If market conditions allowed the cutting of logs into odd lengths, it would be possible to vary log lengths in the woods sufficiently to take much better advantage of defects and crooks, and thus secure the maximum amount of lumber of the best grades. It would also be possible to utilize more merchantable material in the tops.

TRIMMING LENGTHS.

Contracts for the sale of saw timber from the national forests provide in most cases that a certain maximum length shall be allowed for trimming. In logs of less than 30 inches in diameter 2 or 3 inches is usually a sufficient length for trimming; above 30 inches from 4 to 6 inches may be necessary. These figures apply to ordinary conditions, and in cases where logs are to be driven long distances in bad streams, it is frequently necessary to allow greater lengths. From 4 to 6 inches should, however, be sufficient for small timber even in very bad streams.

Some firms allow trimming lengths of from 8 inches to over a foot. This means that over 5 per cent of every 16-foot board is wasted in trimming at the mill. It is, however, difficult to estimate in private operations the average loss per log through excessive lengths for trimming, but it is common knowledge that in most cases lumbermen are careless in checking this waste. It is certainly very conservative to estimate the unnecessary length on all saw logs cut as from 3 to 4 inches.

SHORT LENGTHS.

In most regions common usage, present forms of machinery, and popular prejudice are responsible for the nonutilization of short lengths of logs. In the Rocky Mountains logs are rarely cut shorter than 12 feet, and in most operations lengths of 14 and 16 feet are preferred. In the Northwest 16 feet is considered a very short length and longer lengths are preferred. In the Sierras 14 feet is the minimum length, while 16 and 18 feet are the shortest lengths to which logs are cut in most operations. In the Southwest logs in a few operations are cut to a minimum length of 12 feet, while in rare cases lumbermen may cut to 10 feet; as in the Rocky Mountains, however, 14 and 16 feet are the common minimum lengths. In the pine forests of the South a minimum length of 10 feet is unusual, and logs are commonly cut 12 feet or more. In the hard-wood forests, with the exception of hickory, pulp material, mine props, and stave and heading blocks, logs are not cut below 8 feet in length.

In the Adirondacks 4-foot pieces are now used for pulp, and in New England spruce for pulp is frequently cut to 10 feet.

The following gives an idea of the minimum lengths of timber of various grades and the lengths which can be utilized for various purposes. These data indicate at least that log lengths could be reduced considerably for many species:

Cypress.—Tank, clear, select, shop, 10 to 20 feet; shorts in clear and selects, 12 inches to 8 feet; finishing, 10 to 20 feet; flooring, ceiling, drop siding, molded casing, and base or short lengths, 10 to 20 and 4 to 8 feet; turning stock, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 42, and 48 inches; common lumber, 10 to 20 feet; pickets, 2 to 4 feet; car siding, 8 and 10 feet; car roofing, 5 and 6 feet.

Bay poplar (*Tupelo*).—Flooring or ceiling, 6 to 20 feet; bevel sidings, 10 to 20 feet; drop siding, 10 to 20 feet; box boards, 12 to 16 feet; clears, 10 to 20 feet; No. 1 common, 6 to 20 feet; No. 2 common, 4 to 20 feet.

Douglas fir (*coast*).—Flooring—vertical grain, 6 to 16 feet; flooring—flat grain, 10 to 16 feet; ceiling, 10 to 16 feet; partition, 6 to 16 feet; porch decking and ceiling, 4 to 16 feet; drop siding and rustic, 10 to 16 feet; stepping, 6 to 16 feet; finishing, 6 to 16 feet; windmill stock, 10 to 40 feet; battens, 8, 16, 18, and 20 feet; common boards, 6 to 20 feet; joist and scantling, 6 to 32 feet; bridge stringers, 32 feet and under; car sills, 34, 35, 40, 41, 45, 46, and 50 feet; timbers, 32, 44, 51, 55, 56, and 60 feet.

Spruce (*coast*).—Finish, 6 to 16 feet; thin finish, 6 feet and up; flooring and ceiling, 10 to 16 feet; wainscoting, 4 to 6 feet.

Southern yellow pine.—Common boards, 10 to 20 feet; fencing, 10 to 20 feet; dimension, 10 to 20 feet; heavy joists, 10 to 24 feet; timber, 10 to 32 feet.

Redwood, 3 to 5, 6 to 9, and 10 to 20 feet.

White ash.—Poles, 12 feet long; handles, 38 inches long.

Ash.—Scythe snaths, 5½ feet long.

Elm.—Sleigh runners, 16 feet long.

Fir (*Douglas*).—Bobsleds, 12 feet; grain tanks, 18 feet long; hay stackers and sweeps, 18 feet.

Hickory.—Axles 12 inches, bolsters 6 inches, bolster stakes 20 inches, doubletrees 52 inches, eveners 4 feet, handles 42 inches, butts 42 inches long, neck-yokes 50 inches long, oxbows 5½ feet, singletrees 38 inches, spokes 30 inches long.

Maple.—Axles 6 feet long, bobsleds 4 to 8 inches and 7 feet, harrows 14 feet, sleigh beams 4 feet long.

Oak (*white or red*).—Bolsters 6 inches, poles 12 feet long, reaches 12 inches.

Oak (*red*).—Bottom cleats 9 inches, brake woods 6 feet.

Oak (*white*).—Bolsters 6 inches, bottom cleats 4 feet 9 inches, plow beams 7 feet long, plow and cultivator handles 60 inches, plow standards 28 inches, poles 12 feet, reaches 16 inches, sand boards 2 inches, spokes 30 inches long, tongues 12 feet long.

Pecan.—Oxbows 5 feet long.

Pine (*longleaf yellow*).—Poles 12 feet, pole (stock grade) 16 feet, harrow eveners 17 feet, hayloader parts 16 feet.

Pine (*long and short leaf yellow*).—Stub tongue 12 feet.

Poplar.—Wagon box boards 16 feet.

BREAKAGE.

The amount of breakage in felling varies greatly in different operations in the same region and with different species. Much of course depends upon the roughness of the ground and sometimes also on weather conditions; as, for instance, in very cold weather the breakage of many species is materially increased. Carelessness is responsible for quite a large portion of loss through breakage. Here again the position taken by the logging foreman may materially increase or decrease the amount of loss, and much depends upon the experience of the men actually engaged in the work. In some operations there is a considerable percentage of loss through improper notching of trees which are to be felled and the splintering which follows. The damage which is done to young growth through careless felling is probably least often considered, and it is certain that the damage to future crops from this cause is very great. No other result can, however, be expected when so few lumbermen are cutting with a view to a second crop.

In logging operations in which it is necessary to use chutes the breakage is often considerable from poorly constructed or poorly operated chutes.

AXES V. SAWS.

In practically all of the lumbering operations of the present time the saw has displaced the ax for felling and cutting. Formerly, however, it was the practice to use the ax almost altogether. In cordwood operations the use of the ax is still common, and the resulting loss is just as great, if not greater, than in a saw-timber operation, because cordwood is cut into shorter lengths.

DONKEY ENGINES.

In some parts of the West the destruction of quite a large percentage of the timber which is left may be attributed to the use of donkey engines in logging. Wire chokers are slung on young trees, which are usually so badly damaged as to be worthless. Many other trees which are left are seriously barked by the use of cables, and drag ways are selected with no thought for the protection of reproduction.

DAMAGE IN SKIDDING AND HAULING.

While it does not decrease the amount of merchantable timber in a logging operation, the damage to young trees through barking in the skidding or hauling operation must be considered because of its relation to future cuts. Such wounds, if serious, result in killing a tree altogether, or in other cases allow infection by fungi, so that before a second operation the tree becomes partially or wholly worthless.

LOSS IN DRIVING.

Although the use of logging railroads is fast taking the place of driving, in some parts of the North and Northwest the drive is still common. In logging operations, which include only spruce, 1 per cent of the amount driven may be considered a legitimate loss. In operations which include pine, either the white pine or Norway pine of the North or the southern pine, 10 per cent on the average may be considered a legitimate loss. In driving, of course, much depends upon the age and quality of the timber; for instance, old timber floats much better than young timber in which the amount of sapwood is proportionately large; defective timber becomes water-soaked much quicker than that which is sound, and the loss is, therefore, correspondingly greater. The surveyor-general of the second district in Minnesota, in which district 90 per cent of the timber cut is driven, estimates that 5 per cent of large white pine is lost in driving; that an average of 10 per cent of small white pine and spruce and large Norway is lost, and that the loss in tamarack, balsam, and small Norway will average 15 per cent. The use of logging railroads obviously does away with all loss which results through driving. Another kind of loss must, however, be considered—that of the use of ties. Ties used in logging operations are rarely removed, even though they are sound when the steel is taken up. It is true that many of the ties used in such an operation are made from inferior trees, or inferior species of trees, but, on the other hand, it is very common to use for ties many of the young and thrifty growing trees which might be left to good advantage to form the basis for a second cut.

INDIRECT LOSS THROUGH FIRE.

Practically all of the lumbermen of to-day are cutting in such a way as to obtain a maximum present profit, and are not considering conservative forest management or even a second cut. It is natural therefore that all slash and débris should be left without consideration of protection of the cut-over area. Upon such cut-over lands it is quite certain in most regions that fire will follow. This fire in addition to destroying the slash destroys the greater part of the merchantable timber left, practically all of the young and thrifty growing timber which has escaped the lumbering operations, and what is worse, destroys practically all of the reproduction and in many cases seriously damages the soil itself. Many years must elapse before such fires are followed by even scattering seed trees and, in extreme cases, it is certain that several hundred years will pass before the soil is in any condition to produce even an average crop.

The proportion of cut-over lands upon which fire follows logging operations varies considerably with the species involved. In the eastern white pine belt practically all of the cut-over lands are burned over sooner or later. Upon the greater part of such lands reproduction of the valuable species at the present time is coming in very slowly, because of the comparatively small number of seed trees which have escaped. In the spruce belt of the Northeast, it is estimated that approximately 25 per cent of the lands cut over for saw timber and 50 per cent of the lands cut over for pulp have afterwards been burned over. In the southern pine belt fire follows cutting in almost every instance. The damage to the remaining trees is not, however, so great as in the North and Northeast, and even reproduction, after it has reached a height of from 3 to 10 feet, usually escapes.

In the coniferous forests of the Rocky Mountains and the west coast fire also follows cutting in almost every instance, and the damage in such forests is usually very great, sometimes killing practically all of the trees which have been left in the lumbering operations. In the hardwood regions fire probably follows lumbering much less frequently than in coniferous forests.

While the damage from fire on cut-over areas is only an indirect result of logging operations, the amount is almost beyond comprehension. As has been stated, fire not only destroys the trees and reproduction which have been left, but also seriously damages in many cases the soil itself. As a general rule, such fires extend beyond the cut-over areas and do a great amount of damage to virgin forests.

INDIRECT LOSS THROUGH WINDFALL.

In some parts of the country the damage through windfall which follows lumbering operations is serious enough to be considered. In New England it is estimated in some cases that such injury, when the cutting has been very heavy, exceeds that done by fire. In other parts of the United States the damage through windfall may consist only of the blowing down of isolated trees and the loss may be comparatively small. Trees blown down in this manner are usually a total loss, since cutting operations have usually been so heavy that it will not be possible to return for a second cut before the windthrown tree has become unmerchantable.

It is the custom in some parts of the United States to transport logs a part of the distance to the mill from the cutting area by rolling them down steep slopes. This practice, while it is very local and relatively of small importance, results in the destruction of practically all of the trees and reproduction in narrow strips.

REPRODUCTION AND FUTURE CROPS.

Since the lumberman is not, except in special cases, considering conservative forest management or even a second cutting, it is natural that he should not insist upon protection of the trees which are left and of reproduction. Reproduction in most cases suffers in almost every phase of the logging operation. The tree is felled, skidded, and hauled regardless of the number of young and thrifty trees which will be damaged. Young and thrifty trees of the valuable species are cut for various kinds of construction purposes, when inferior trees or dead timber are just as available and could be used at a slightly increased cost or at a slight disadvantage. It is exceedingly difficult, if not altogether impossible, to estimate the loss to future cuts through disregard of young growth. Indirectly the ultimate loss may be arrived at through the longer time required to produce a second cut. When, in addition to the direct damage to young growth in logging, fire follows as a result of the slash left, the result is much more serious. Under conservative methods a second cut in, for instance, the Northeast could be provided for within fifty years. If, however, the protection of reproduction is disregarded and fire follows a lumbering operation, it may be necessary to wait two hundred to three hundred years or even much longer to obtain a second crop.

Although the actual present loss of reproduction from any area seems of small importance, the economic loss in such cases probably far outweighs the loss through the other forms of wasteful methods already discussed.

The practice of cutting valuable species and leaving the inferior species for seed trees upon an area is also decidedly objectionable when the future crop is considered. Such practice makes it certain that the second crop of timber will be made up chiefly of inferior species, with only a small proportion of the more valuable species which form the present stand.

In the Rocky Mountains and in some parts of the Sierra and coast regions a very heavy cut and the destruction of existing reproduction sometimes result in a stand of chapparal in which it will be exceedingly difficult to bring about forest reproduction. In other parts of the West where reproduction is very light, it is probable that parks will be formed, and in many cases that the existing parks will be enlarged through the removal of too great a portion of the stand and the destruction of reproduction. The grazing upon such parks will, of course, be valuable, but present conditions indicate that the demand for and profit in timber will be greater than the demand and profit for grazing lands.

When we consider the fact that through the careless methods of to-day we are either delaying second and future crops of timber and providing for crops of inferior trees, or perhaps destroying almost all chance for future timber growth, the importance of carefully protecting all young growth is most clear.

Because of the comparatively high prices for lumber, the operator of to-day is in many cases removing trees of small diameter which are just about entering the period of best growth.

Data collected by the Forest Service show that with all species and with all market conditions there is a definite diameter limit, varying in each case with conditions, below which trees can not be cut and removed at a profit.

The following table from Forest Service Bulletin No. 73 shows the actual value of the material cut from yellow poplar trees of various diameters. The data were obtained in mill-scale studies which took account of both quality and quantity of the material produced. In the region in which the studies were made the cost of the logging was approximately $15 per thousand feet, board measure, and accordingly trees smaller than 19 inches in diameter could be logged only at a loss. On trees of 19 inches in diameter the profit, which increased rapidly for larger sizes, was only 34 cents for the thousand feet:

Values of yellow poplar—Virginia, 1905.

Diameter breast-high.	Amount sawed out.	Value per tree.	Value per thousand board feet.	Diameter breast-high.	Amount sawed out.	Value per tree.	Value per thousand feet.
Inches.	*Board ft.*			*Inches.*	*Board ft.*		
13	104	$1.38	$13.27	23	590	$10.61	$17.98
15	171	2.31	13.51	25	761	14.90	19.58
17	246	3.43	13.94	27	948	19.80	20.89
19	341	5.23	15.34	29	1,170	26.22	22.41
21	455	7.53	16.55	31	1,386	32.74	23.62

II. LOSS IN GIVEN OPERATIONS.

Very little data to show the actual amount of material unnecessarily wasted have been collected, some of which are incomplete and do not apply to the conditions of to-day. Practically all of the data given have been collected by members of the Forest Service. In each case these data show not the total waste, but the material which under existing conditions could have been utilized, that is, the unnecessary waste. As previously stated, perhaps the most important part of the waste—the destruction to young growth—can be estimated in the difference of time required to obtain second and future crops under the usual and conservative logging methods.

LOGS.

The following data collected in the year 1899, taken from Forest Service Bulletin No. 26, show the waste in spruce saw-timber logging:

(1) Percentage of entire cut wasted through the cutting of needlessly high stumps, 2.

For every 100,000 standards cut 2,000 standards were wasted because of needlessly high stumps. On a tract of 100,000 acres, with an average stand of 15 standards to the acre, the stumpage valued at 40 cents, the actual loss according to these measurements would have been $12,000.

(2) Unnecessary loss through leaving tops which might have been utilized, 6½ per cent of the total cut. It is estimated, however, that the actual value of the material wasted in tops averages only one-fourth as much as that left in high stumps.

(3) Unnecessary loss in building skidways which were not afterwards removed, about one-fourth standard per acre, or 1½ per cent of the total cut in a stand of 15 standards to the acre.

(4) Loss in building roads not estimated, since trees generally used were small and not merchantable under existing market conditions.

(5) The injury done in skidding was mostly to young growth, unmerchantable under existing market conditions, and an estimate was therefore impossible.

(6) Injury done in hauling included the cutting of spruce on steep hills. Although trees of all sizes were cut, the greater part were so small that an estimate of the waste could not be made.

Thus making a total loss of 11 per cent, as follows: (1) 2 per cent; (2) 2 per cent, 6½ per cent, and 1½ per cent; (3) 1½ per cent; (4), (5), and (6), taken together, 1 per cent.

This estimate does not include the sound logs left in the woods and lodged trees which were not felled.

The following data taken from the Forest Service Bulletin No. 30 show the difference in the amount of material obtained when cutting is done by ax or saw. The tree taken, if cut with the saw, would yield 1.26 standards; if, on the other hand, it were cut with the ax it would yield 1.19 standards, making a loss of 0.07 of a standard by using the ax. This loss is equal to one-half of 1 per cent of the total amount obtained by using the saw.

The following data are taken from the Department of Agriculture Yearbook for 1905: "Waste in logging southern yellow pine." The timber in this case was cut by a lumber company which had bought the timber from a land company, with the provision that payment be made upon the basis of the scale of the timber actually removed.

These measurements were taken in the year 1904, and are a fair indication of the amount of waste in southern pine operations at that time. All the measurements given were taken after logging apparatus had been removed from the cut-over land, so that there was no possibility of returning for the timber left. Measurements covering 300 acres show that more than 6 per cent of the large trees left standing after logging was completed was defective, which in all cases contained one or more good logs. Further measurements showed that of a total number of small and thrifty trees which were considered unmerchantable because of their size (trees below 17 inches at the stump) and were therefore left, 25 per cent was broken, knocked down, or in some way incapacitated for further growth, due almost entirely to careless logging methods. Of the total number of sap trees destroyed by logging it was found by actual count that one-fifth were cut for skid poles. In a stand which would average 10,000 feet b. m. to the acre of merchantable timber the amount of waste in tops per acre was 667 feet and the amount of unnecessary waste in stumps averaged 218 feet. Eight and eight-tenths per cent therefore of the total stand was unnecessarily wasted in tops and stumps. In addition it is estimated that in the ways indicated above 13 per cent of the total cut was wasted in merchantable trees left uncut and in merchantable material cut and left.

The following data taken from the report of the forestry commission of Maine for the year 1896 show the waste in cutting saw timber and pulp. The Maine rule was used in taking the necessary measurements, except as indicated.

In one case in which utilization was thought to be conservative, Mr. Cary, the author of the article, says that 36 per cent of the material on the tract was utilized, 47 per cent was needlessly wasted, and 17 per cent was left to grow. Measurements taken on the Kennebec River showed that 33⅓ per cent of the trees actually cut was wasted in stumps and tops, and Mr. Cary further states that this is a good average for the region at the time the cutting was done.

Another series of measurements showed that 71 per cent of the merchantable contents of the trees cut was utilized. In this case, however, men were cutting from their own land, and naturally logged more carefully than if the work were being done by contract.

In still another case measurements show that in trees up to 14 inches in diameter, 57 per cent of the merchantable contents of the trees cut was actually utilized, and that in the case of trees over 14 inches, 66 per cent of the merchantable contents of the trees cut was utilized. This cutting was done by a purchaser of stumpage in virgin timber in which the trees were comparatively large and the waste should have been small.

In another series of measurements on still another cutting in which the circumstances and locality were the same as for the data last given, 56.9 per cent of the material cut was saved. For another region the measurements (Blodgett rule) taken show that 84 and 86 per cent of trees cut under and above 14 inches, respectively, were actually utilized. A series of measurements where the cutting was done by owners of land for their own mills shows that with trees up to 14 inches in diameter, approximately 70 per cent of the material was utilized, and with trees over 14 inches 72 per cent was utilized. These data include only the waste in stumps and tops and not the valuable material used in road construction when other timber was available, partly merchantable trees which were not cut at all, and the loss occasioned by disregard of reproduction.

Measurements taken on 32 trees cut on the Fort Wingate Military Reservation showed that 23 per cent of the merchantable contents of the trees cut was wasted in tops and stumps.

In a national forest sale in southern Wyoming in a stand made up of Engelmann spruce and lodgepole pine, chiefly the latter, 58 per cent of the total cut was utilized as hewn railroad ties, 24 per cent as mining props, and 18 per cent as saw timber. In many of the old operations of this region ties were cut and the timber suitable for other materials, such as props and saw timber, was left in the woods. In many other operations materials other than ties and saw timber have not been utilized. It is obvious, therefore, that in such cases about 24 per cent of the merchantable material, on the basis of the sale above mentioned, was left in the woods.

The following extract from Forest Service Bulletin No. 69 gives an idea of the utilization of valuable species, such as the sugar pine. While utilization was close under the existing conditions, it is much more so at the present time because of still higher market prices.

> From a financial standpoint there is almost no waste in logging, though often the actual waste of timber is considerable. Stumps are cut 3 feet in height or even less, merchantable logs are seldom left in the woods, and the trees are cut fairly well into the tops. The size at the end of the last log varies a good deal with the character of the individual tree. In general, logs are cut to about 14 inches at the small end, though occasionally they may be cut as small as 10 inches.
>
> From what has been said it may be judged that the lumberman is beginning to realize the necessity of logging as closely as possible. How close he may log must depend on his particular operation and the attending conditions. Since these conditions vary greatly, it is natural that the economy of logging operations should also differ widely. Most of the large concerns are now hauling to their mills sugar-pine logs that have been lying on the ground thirty or forty years. The sapwood of these logs has, of course, rotted away, but the heartwood is usually as sound as on the day the trees were cut. One big lumber company is cutting its tops and limbs into firewood, which it handles at a small profit per cord. This it is enabled to do by the existence of a good market near at hand, with which it is connected by its own railroad.
>
> At least one company has reduced its loss in the fire-scarred butts of sugar pine to a minimum, for it cuts the butt log as though the fire scar did not exist, hauls it to the mill, and as far as possible, cuts it into full-length boards. What is left is then cut into "shorts."

The following extracts from an article in the Dixie Wood Worker of December, 1905, gives a lumberman's estimate of the loss in logging in the southern pine region:

CUT THE STUMPS LOWER.

> Most woods foremen allow the stumps to be cut too high. From 2½ to 3 feet is the average in the southern pine region. * * * Nevertheless, the southern pine woods foreman permits a large amount of timber to be ruined by allowing his saw crews to fell timber across stumps, or down timber, and to break off standing trees by the falling of others against them. The appearance of most cut-over pine land in the South shows how very great the damage is from this source. The ground is strewn with broken tree sections which have been butted out, and is dotted here and there with the splintered trunks of promising young trees deprived of their crowns. In heavy stands of southern pine as much as 400 feet per acre on an average is sometimes destroyed by the careless felling of timber. A zealous woods foreman would put an end to a

> large part of this careless waste by insisting that the sawyers use the greatest caution in felling timber. A certain amount of breakage is, of course, unavoidable, but most of it is due to sheer carelessness on the part of shiftless workmen. Such men often waste wantonly several times their wages in timber. Summary discharge of the conspicuously careless would have a good effect on the rest of the men. * * *
>
> A good woods foreman will impress on his saw crew the importance of so arranging their log lengths that a bad defect, such as a punk knot or rot hole, will come at the end of the log rather than in the middle of it. In many cases it would be best to butt out the bad place. If left in the middle of the log, however, it is impossible to trim the defective boards at the mill, and they must grade as No. 2 or No. 3 common.
>
> Another bad arrangement of log lengths is to run the end of an otherwise clear log just beyond a large knot or pitch pocket, making it necessary to trim away the defective end in order that the boards may grade as clear. The defective part might just as well have been put into the next log, which is knotty and will make only the lower grades.
>
> ### DECIDING ON WHAT LOGS TO CULL.
>
> The skill of the woods foreman is never tried more severely than when he decides what logs are not worth sending to the mill. Crooked, hollow, swell-butted, and doty logs, each is a problem in itself, and at best the judgment of the foreman is only guesswork. Close observation of what defective logs saw out in the mill will, however, enable him to guess more accurately from day to day. Lumber companies waste a great deal of money by sawing timber so small or defective as to be not worth taking; on the other hand, other lumber companies waste money by leaving in the woods timber which really would pay for the taking. I know of an instance where a lumber company operating in southern pine in one of the Gulf States made it a practice to leave in the woods all knotty, top logs below a certain diameter. The cut-over lands of this company are strewn with tops, many of which contained logs 10 to 18 feet long, more or less knotty. The company based its rule on the assumption that such logs would not saw out anything better than No. 2 commons; yet a study of the results from sawing this same class of material in a neighboring sawmill disclosed the fact that they yielded enough of No. 1 commons to afford a nice margin of profit.

The great item of waste in logging in the Northwest is breakage, and a little additional height in the stumps, which may seem unnecessary, really reduces, it is claimed, to a great extent the loss which might otherwise occur from this cause. In the larch operations of northern Montana, Idaho, and eastern Washington, lumbermen consider it necessary to cut off quite a large piece of the butt log of large trees in particular. This, in operations in the national forests where it is necessary to drive the logs which are utilized, amounts to as much as 5 or 10 per cent of the total cut of the species. In private operations, however, the loss from this practice alone is very much greater. The great percentage of loss in redwood operations is too well known to require comment. No accurate data, however, are available.

The utilization of saw timber throughout the hardwood region is, as a rule, very incomplete. In parts of the hardwood district in which coal and gas are available and cheap for fuel, all of the material suitable for cord wood must be left, in addition to the waste in the saw-timber product. In other parts of the hardwood region where coal and gas can not be obtained at low rates, the material which is not utilized for saw timber is disposed of as cord wood. Frequently, however, far too much material which is suitable for saw timber is worked into cord wood. The Doyle scale rule, which is almost universally used in the hardwood district, is perhaps responsible to some extent for the waste, on account of the very small value it allows for small logs.

Forest Service Bulletin No. 73 states that by a judicious selection of the proper lengths for cutting logs as much as 25 per cent may be saved in some cases. It is necessary for the woodsman to be able to judge accurately from the outside appearance of the log the kind of lumber which it will cut. The appropriate selection of log lengths throws serious defects into such parts of the log that the amount of waste is reduced to a minimum.

In the report on "Forest conditions in Kentucky," Messrs. Holmes and Bradfield, of the Forest Service, estimated that the waste in floating, weathering, and discoloring in driving logs amounts to at least 10 per cent, and if logs are stranded or in any other way delayed for two or more seasons in reaching the mill this loss amounts to 15 to 20 per cent.

Mr. Patterson, in a report on the cutting of a company in western Kentucky, states that stumps are cut from 22 to 30 inches in height, and that the average loss per tree at the stumpage rates paid in the year 1905 was 15 cents.

SHINGLES.

The great bulk of shingles which are made in the East are manufactured from material which would otherwise go to waste; that is, from slabs, short pieces, etc. In the West, however, particularly in the cedar district of Washington and in Oregon, operations in which cedar is the only product are common. Stumps are necessarily cut very high, since, on account of the grain, a good grade of shingles can not be made below the point at which the butt swell begins. These stumps, however, are not very much higher than stumps in a saw-timber operation. Cedar for shingles can not be utilized so far into the tops as saw-timber material on account of limbs and knots, but this waste is not so great as might at first appear, because of the very rapid taper of the average cedar tree. Operations confined to cedar for shingles alone usually result in considerable damage to the remaining timber which is not removed. Since many of the cedar-shingle operations of the present time include only dead timber, utilization in that respect may be classed as very complete. The fact that cedar is split into bolts before manufacture is responsible for quite a large percentage of waste.

PULP WOOD.

Considerable data have already been given regarding waste in operations in the Adirondacks and New England in pulp-wood operations. The great bulk of pulp wood is obtained from the spruce region of the Adirondacks and the Northeast, and, as a rule, utilization at the present time is wonderfully complete. As previously stated, tops are commonly taken to a diameter of 5, or even 4, inches, and stumps are cut low.

WOOD FOR DISTILLATION.

Utilization in the woods for materials to be used for distillation is probably as complete as for any other operation in the United States to-day.

HEWED CROSS-TIES.

The following extract from Forest Service Circular No. 118 gives an idea of the waste in tie making in eastern hard woods.

Tables 1 and 2 give a clear idea of the wastefulness of the present methods of tie production. Out of every 100 trees cut for ties over 63 are taken to a top diameter of from 10 to 13 inches instead of 9 or 9½ inches, the smallest diameter from which a 6 by 8 inch tie can be made. Out of 100 trees of 14 inches and over whose butt logs could be split, two-thirds remain entirely unsplit, and of the remainder only a small number are split into the number of ties justified by the size of the logs.

Table 1 brings out strikingly the wastefulness of the present manner of tie cutting. Where ties were being cut, 100 trees, embracing all diameters from 10 to 19 inches, were measured, the actual number of ties yielded by each ascertained, and the total cubic contents of each of the trees, as well as the contents of the portion used for ties, computed.

TABLE I.—*Waste in producing slab cross-ties.*[a]

Diameter of trees breast-high.	Volume of usable length of tree.	Volume of used length of tree.	Ties produced.	Waste of used length of tree.		Waste of usable length of tree.		Wood used for one tie based on used length of tree.	Wood used for one tie based on usable length of tree.
Inches.	*Cu. ft.*	*Cu. ft.*	*Number.*	*Cu. ft.*	*Per ct.*	*Cu. ft.*	*Per ct.*	*Cu. ft.*	*Cu. ft.*
10	14.3	6.1	1.3	2.6	43	10.8	76	4.7	11.0
11	18.5	9.5	1.7	5.0	53	14.0	76	5.6	10.9
12	22.7	12.8	2.1	7.2	56	17.1	75	6.1	10.8
13	27.0	16.2	2.5	9.5	59	20.3	75	6.5	10.8
14	31.8	20.0	2.9	12.3	62	24.1	76	6.9	11.0
15	37.6	24.5	3.3	15.7	64	28.8	77	7.4	11.4
16	45.0	29.6	3.7	19.7	67	35.1	78	8.0	12.2
17	54.5	35.7	4.2	24.5	69	43.3	79	8.5	13.0
18	65.5	43.1	4.7	30.6	71	53.0	81	9.2	13.9
19	76.5	51.3	5.2	37.4	73	62.6	82	9.9	14.7

[a] Assuming each tie to contain 2.67 cubic feet.

Thus from 43 to 73 per cent of the logs used for ties and from 75 to 82 per cent of the whole tree are entirely wasted. This waste is enormous, if we consider how much wood must be consumed to produce the 20,000,000 or more ties which are each year cut in the region. It amounts to about 221,000,000 cubic feet of wood, on the basis of the entire merchantable contents of the tree, or 140,000,000 cubic feet of logs, on the basis of the part actually cut. Of the total amount of timber cut for ties nearly three-fourths is wasted. That this waste can be much reduced is proved by tie cutting in Germany. There also the majority of ties are hewed, while the common tie is larger than our standard tie. It is 8.17 feet (2.5 meters) long, has 10.2 inches (26 cm.) face, is 6.29 inches (16 cm.) thick, and contains 3.5 cubic feet instead of our 2.67 cubic feet. Yet in Germany it takes only from 4.4 to 5 cubic feet of log to produce one tie, while in this country it takes on an average from 7.5 to 8 cubic feet of log to produce a smaller tie. In spite of very strict specifications, the waste of timber in hewing does not there exceed 30 or 40 per cent of the log, while in this country it reaches 73 per cent, to say nothing of the top, which remains entirely unused. The waste in hewing oak ties is greater than in hewing pine ties, since it takes about 11 cubic feet of hardwood timber to produce one tie, and only 9 cubic feet of pine wood. This is due not to any greater waste necessarily involved in hewing hardwood ties, but to the smaller taper and proportionately longer clear length of the pine as compared with oak.

With no inspection of the sizes and characters of the trees cut, the tie makers are guided in their choice of tie timber and the portion of each tree to be used for ties merely by their own convenience and by the ease with which the trees may be hewed into ties. By taking each tree to a top diameter of 9 inches outside the bark, cutting stumps not higher than 2 feet from the ground, and splitting into ties all logs large enough, an increase of from 67 to 185 per cent can be effected in the yield of individual trees above 15 inches in diameter.

This is shown in Table 2, which compares the average number of black-oak ties obtainable under the present practice and the number possible under more economical methods of tie cutting. The possible yield of ties per tree is based on the taper measurements of black oak.

TABLE II.—*Comparison of the average number of black oak ties per tree obtained under present practice, with the number possible under more economical methods of tie cutting.*

TIES CUT.

Diameter breast-high.	Under present practice.	Under more economical methods.	Increase.
Inches.	*Number.*	*Number.*	*Per cent.*
[a] 12	2.7	3.0	11
13	3.0	3.6	20
14	3.3	4.3	30
15	3.6	5.9	64
16	3.9	6.5	67
17	4.2	8.0	90
18	4.5	11.1	147
19	4.9	13.5	176
20	5.4	15.4	185

[a] Trees under 12 inches can not be used economically for ties.

Under more rigid supervision the present yield in ties per acre could in a great many cases be doubled and even trebled, if all trees large enough were made into ties. At present many trees are left uncut, not out of consideration for the future of the forest, but because they are too large, tough, or crooked to be easily hewed into ties, while the straightest and youngest trees are taken because they yield the greatest number of ties with the least effort. Table 3 gives the actual yield of 15 sample acres and an estimate of what could be obtained from them if all the trees of tie size were made into ties under present methods and under more economical methods.

TABLE III.—*Comparative yield of ties per acre under present sytsem and under more economical methods.*

Age of stand (years).	Type.	Actual yield of ties.	Yield by taking all trees of tie size by the present methods.	Possible yield of ties by taking and fully utilizing all trees of tie size.
		Number.	*Number.*	*Number.*
80	Slope	62	106	107
50 to 60	do	38	165	247
48 to 51	Cove	62	209	254
49 to 51	Ridge	100	191	211
60 to 80	Slope	123	140	218
80	do	90	152	154
50	do	48	113	340
53 to 60	do	46	66	94
55 to 65	do	21	52	113
55 to 70	Ridge	23	131	163
56 to 60	do	27	103	121
58 to 60	Slope	46	109	117
60 to 65	do	34	70	102
65 to 70	do	42	105	112
68 to 73	Ridge	54	162	187

By taking all trees that can be made into ties, even as cutting is now practiced, the yield per acre would be increased by from 60 to 125 ties, and with the closest utilization of each tree an increase of 170 ties might be secured from each acre. In this way, to supply the required number of ties, the forest area now annually cut over for ties could be reduced nearly two-thirds and the revenue per acre increased.

The greatest economy would be effected in the utilization of the timber if all trees above 13 or 14 inches in diameter were sawed instead of hewed into ties. Where sawed ties are as readily accepted as hewed ones, and where logging is not difficult, sawing will usually prove cheaper and more profitable than hewing.

The following data from Forest Service Bulletin No. 64, published in 1905, give an idea of unnecessary waste in cutting ties in Texas:

WASTE IN HEWED TIES.

Since the tie inspectors do not object to, but even favor ties of greater dimensions than 6 inches by 8 inches, the tie maker never hews a large log to the minimum size. A hewn tie therefore contains as a rule more than the 32 board feet which are contained in a sawed tie of the specified dimensions. This waste of timber, though considerable, is less than that which goes into slabs and chips in hewing.

Table XXV is compiled from records made of the actual yield of 603 trees, and conveys an idea of the sum of these wastes. It shows that from 54 to 71 per cent of the timber cut for pole ties goes into slabs and excessive dimensions. If to this waste is added the timber lost in unreasonably high stumps, and the large tops left entirely unused, the proportion of the tree actually used in the shape of ties is exceedingly small. Thus, only from 26 to 30 per cent of the total volume of the tree is made remunerative, while the rest, 70 to 74 per cent, is either thrown away entirely or practically wasted in making needlessly large ties. These figures of course include some material that could not be used in any case, e. g., the tops above 9 inches. The statement is made in this way solely to show how small a proportion of the forest is utilized and to emphasize the importance of the economies that are recommended farther on.

TABLE XXV.—*Amount of timber wasted by making hewed pole ties.*

Diameter, breast-high.	Total volume of tree.[a]	Volume of round logs in used portion.	Volume of ties cut (6 by 8 inches by 8 feet).	Volume wasted.	
				In portion of tree used for ties.	In the whole tree.[a]
Inches.	*Cu. ft.*	*Cu. ft.*	*Cu. ft.*	*Per cent.*	*Per cent.*
11	24.5	12.9	6.4	50	74
12	31.0	18.0	8.3	54	73
13	36.5	24.2	10.4	57	72
14	42.5	31.6	12.8	60	70
15	48.0	39.3	13.9	65	71
16	55.0	46.8	15.2	68	72
17	62.0	54.3	16.0	71	74

[a] Exclusive of branches.

The figures of the average number of ties actually yielded by trees of different diameters, Table XXIV, do not represent all that could be obtained from the same trees under a more careful and economical system of cutting. Since the tie makers are paid by the tie, their aim is to make as many as possible in the shortest time and in the easiest way. They commonly avoid all crooked and knotty trees, and fell only the tallest and straightest ones, those which will yield the greatest number of ties. Because the butt of the tree is tough and requires most ax work, the stumps are cut as a rule excessively high, seldom less than 2.5 feet in trees of small diameters, and often 3 feet to 4 feet in the larger trees. Many trees, after being felled, are also butted off 3 or 4 feet, because they are too large to be hewed easily. Another means of saving work is to saw the trees through about three-fourths of their thickness, and throw them by means of wedges driven into the kerf. In falling, the tree splits up for a considerable length and leaves a long slab attached to the stump which would otherwise have to be taken off the log by the ax. Old suppressed trees, which after being felled prove hard to hew, are frequently left to rot, or only a small part of what could be made into ties is used. Most of the trees felled for ties could be safely used to a diameter of 9 inches in the top, but the tie cutter, guessing at the size and unwilling to risk making a cull tie (one below the specified dimensions), for which he is not paid, remains on the safe side and seldom cuts beyond 10 inches. Often a large part of a tree with a knot or crook, or slightly buried in the sand so that it is difficult to saw into the proper lengths, is left unused.

POSSIBLE SAVINGS IN TIE MAKING.

Many of the wastes that have been just described are easy to reduce or to eliminate entirely. By merely cutting the stumps about 2 feet high or less and utilizing all the tie timber in each tree the average number of ties to the tree could be perceptibly raised.

Table XXVI shows clearly how great a saving may be effected by cutting all stumps at 2 feet above the ground and utilizing the stem to 9 inches in diameter outside the bark at the top. The figures are based upon taper measurements of 603 trees.

TABLE XXVI.—*Average number of hewed ties now obtained from loblolly pine and number that can be cut.*

Diameter breast high.	Number obtained.	Number which can be obtained.	Percentage of increase.
Inches.			
11	2.4	2.5	4
12	3.1	3.5	13
13	3.9	4.5	15
14	4.8	5.5	15
15	5.2	6.0	15
16	5.7	6.5	14
17	6.0	7.0	17

The increased number of ties that it is possible to obtain is somewhat variable, because lengths of 8 feet must always be cut, yet the gain is very real, and amounts to considerable when applied to even 1 acre of forest. Taking the figures of Table I as an example, it requires but a simple calculation to show that the 93 trees between 11 and 17 inches in diameter produced by 1 acre of forest from 35 to 40 years old may yield 45 more ties than they do ordinarily. If this be applied to a piece of land yielding 40,000 ties, the increase will amount to at least 5,000 ties, worth, at the present price of 24 cents a tie, $1,200.

HEWED VERSUS SAWED TIES.

The hewing of ties, however, no matter how complete the utilization of the tree may be, is a most wasteful process, whose extent will be best understood by comparing the volume of average hewed ties with the product of logs of the same dimensions sawed into ties and lumber. By means of a series of diagrams the amount of lumber and ties which can be obtained from logs of various sizes by sawing has been ascertained. A large part of the log, which in hewing is entirely wasted in the form of chips and excessive dimensions, is thus shown to be available for useful material—boards and planks.

It is impracticable to make a direct comparison between the tie and the lumber yield of trees of various sizes, because the hewers might be more saving, and because the lengths obtainable are not always multiples of the tie length, 8 feet, but such a comparison can be made on the basis of logs 16 feet long, which will produce two ties, or lumber of standard length. This is done in Table XXVII, and the possibility of sawing from 23 per cent of the hewed tie volume, in 10-inch logs, to 191 per cent in 15-inch logs is clearly shown. The saving here indicated may rarely be reached in practice, since the logs are not apt to be perfectly cylindrical nor straight, as the diagrams from which the table was made assume them to be, yet after making every reasonable allowance for such irregularities, the waste in hewed ties is striking.

TABLE XXVII.—*Gain in lumber effected by sawing instead of hewing ties.*

Diameter of log at small end inside bark.	Yield of a 16-foot log—				Percentage of the volume of hewed ties gained by sawing.
	In hewed ties.	In sawed ties and lumber.			
		Ties.	Lumber.	Total.	
Inches.	*Board feet.*	*Board feet.*	*Board feet.*	*Board feet.*	*Per cent.*
10	64	64	14.8	78.8	23
11	64	64	27.0	91.0	42
12	64	64	52.4	116.4	82
13	64	64	70.8	134.8	112
14	64	64	97.2	161.2	152
15	64	128	57.6	185.6	191

TREE SIZES MOST PROFITABLE FOR TIES.

There is a still more important reason why ties should be sawed instead of hewed than the saving of lumber, namely, that the latter method demands those trees which are in their best period of growth. As has been shown, the tie cutters prefer trees 12, 13, 14, and 15 inches in diameter, or between 30 and 50 years of age, when they are still growing rapidly in diameter.

Table XXVIII shows that the rate of diameter increase in trees of the sizes used for hewed ties, though steadily falling, is maintained at more than one-quarter of an inch a year until the age of 50 years is passed.

TABLE XXVIII.—*Increase in diameter of loblolly pine grown in mixture with hard woods on well-drained, fertile soil.*

Age.	Diameter breast high.	Annual increase in diameter.	Age.	Diameter breast high.	Annual increase in diameter.
Years.	*Inches.*	*Inch.*	*Years.*	*Inches.*	*Inch.*
10	2.1	0.40	50	15	0.22
20	6.1	.34	60	17.2	.21
30	9.5	.29	70	19.3	....
40	12.4	.26			

But the loss that is entailed by cutting immature trees is made much more apparent when the increasing money value of the trees is considered. This is shown in Table XXIX.

TABLE XXIX.—*Rate of increase in stumpage value of loblolly pine trees suitable for ties, grown in mixture with hard woods on well-drained, fertile soil.*

Diameter breast-high.	Value of tree at 3 cents a tie.	Annual rate of increase.	Diameter breast-high.	Value of tree at 3 cents a tie.	Annual rate of increase.
Inches.	*Cents.*	*Per cent.*	*Inches.*	*Cents.*	*Per cent.*
11	7.5	8	15	16.5	2
12	9.9	8	16	18.0	....
13	12.3	5	17	18.0	....
14	15.0	3			

These two tables show that the rate of increase in diameter and in value for hewed ties is greater in the smaller trees than in those from 14 to 16 inches in diameter. In other words, the money capital represented by the trees of 11 and 12 inches in diameter increases at a rate equal to an interest of 8 per cent per annum, while the capital represented by trees of from 13 to 16 inches in diameter bears interest at the annual rate of only 2.5 per cent. If the owner of the land were to cut down all the loblolly pine trees between 11 and 13 inches in diameter and place the money received for them in some safe enterprise, he would scarcely receive such a high rate of interest as he does from the growing trees. If it is necessary that the trees should be cut for hewed pole ties, only those 15, 16, and 17 inches in diameter should be used, as their rate of increase in value is smaller than that of trees 11, 12, and 13 inches in diameter. In this way the capital is allowed to work at a higher rate of interest.

Further, the forest is not threatened with entire destruction. In a forest from which regular and sustained yields are expected, trees of all ages must be present and the young ones must preponderate over the old ones, just as in a self-perpetuating community the number of children must be greater than the number of adults. By cutting out the young trees and leaving the old ones, as is now the common rule, the very existence of the forest is attacked. Since hewing the trees into ties instead of sawing them entails more labor and greater waste, it is clear that to get the greatest income from the forest the practice of hewing must give place to sawing.

There is still another consideration. Trees cut for the mill are usually more fully utilized than those cut for hewed ties. Table XXX, based on actual scaling in the woods of trees cut for hewed poles and of the trees of the same diameter cut for the mill, reveals a greater utilization of the trees in the latter case than in the former one, the increase amounting to from 20 to 45 per cent.

TABLE XXX.—*Comparison of the product of loblolly pine grown in mixture with hard woods on well-drained, fertile soil when hewed into ties and when cut into saw logs.*

Diameter breast-high.	Trees cut for pole ties.		Trees cut for saw logs.		
	Number.	Yield per tree.	Number.	Yield per tree.	Excess in saw logs.
Inches.		*Board feet.*[a]		*Board feet.*[a]	*Per cent.*
11	31	35	9	45	29
12	135	53	32	63	20
13	178	70	50	87	24
14	161	90	64	114	27
15	79	108	78	144	22
16	17	125	79	175	40
17	1	145	79	210	45

[a] Doyle-Scribner log rule.

From the point of view of the forest owner, however, this difference is not apparent. At the present stumpage price for lumber and ties he is willing, in the majority of cases, to have his young loblolly pines cut for ties instead of lumber, because the tie timber brings him a slightly higher price per tree, as can be seen from Table XXXI.

TABLE XXXI.—*Comparative values of loblolly pine from all situations, if sold for pole ties or for lumber.*

Diameter breast-high.	Volume of tree.		Value of tree.	
	Lumber.[a]	Hewed ties.	At 75 cents per M. board feet.	At 3 cents per tie.
Inches.	*Board ft.*	*Number.*	*Cents.*	*Cents.*
11	43	2.4	3.2	7.2
12	64	3.1	4.8	9.3
13	86	3.9	6.5	11.7
14	110	4.8	8.3	14.4
15	138	5.2	10.4	15.6
16	171	5.7	12.8	17.1
17	207	6.0	15.5	18.0

[a] Doyle-Scribner log rule.

The smaller value of the tree when cut for lumber is due mainly to the log scales now in vogue, which give an exceedingly low scale to small logs as compared with their actual contents. The extent of this difference is shown on Table 32, though the argument for sawing must rest upon other considerations, since it will be hard to alter the established practice in scaling.

TABLE XXXII.—*Comparative log and tie scales of loblolly pine, grown in mixture with hard woods, actually cut for ties.*

Diameter breast-high.	Scale of the unhewed logs.	Ties cut from tree.	Scale of the hewed ties at 32 feet each.	Excess of tie over log scale.	Diameter, breast-high.	Scale of the unhewed logs.	Ties cut from tree.	Scale of the hewed ties at 32 feet each.	Excess of tie over log scale.
Inches.	*Board ft.*[a]	*Number.*	*Board ft.*	*Per cent.*	*Inches.*	*Board ft.*	*Number.*	*Board ft.*	*Per cent.*
11	35	2.5	80.0	129	15	108	5.5	176.0	63
12	53	3.3	105.6	99	16	125	6.0	192.0	54
13	70	4.1	131.2	87	17	145	6.0	192.0	32
14	90	5.0	160.0	77					

[a] Doyle-Scribner log rule.

In this connection it is proper to consider why trees are hewn at all. One would naturally expect that the persistent demand for hewed pole ties, the production of which is coupled with such a waste of timber and the most extravagant use of the forest, must be based on very good reasons, and that the railroads are paying a higher price than for sawed ties, as is the case with those made of longleaf pine and other woods. As a matter of fact, however, hewed and sawed ties of loblolly pine command exactly the same price in eastern Texas. The apparent reason for the preference is that hewed ties are thought to last longer than sawed ones, because the smooth surface made by the ax is less retentive of the water that promotes decay than is the sawed wood. There may be some truth in this when untreated ties are considered, but since all the loblolly-pine ties now used are treated before they are laid in the track the objection does not hold. According to Doctor von Schrenk,[a] sawed ties when properly treated, last as long as hewed ones, and there is no good reason why they should not be used. The farmers of Texas probably will continue to furnish hewed ties so long as they are demanded, in spite of the drain on their forests, but the railroads can easily curtail the waste by encouraging the production of sawed ties. The railroads are heavy consumers of timber in many forms. Besides ties, they require every year enormous quantities of bridge timber, telegraph poles, and lumber for cars and houses. The present wasteful use of young timber for ties, which could readily be avoided, will lead to a rapid exhaustion of the timber supply in general, which can not remain without influence upon the lumber market.

In some instances the cutting of young timber for hewed ties may be justified. Where the stand is very dense the removal of the trees which lagged behind in the competition for light and room would prove beneficial to the growth of those remaining. Since from the several thousand young seedlings which usually start on an acre only from 140 to 160 trees reach maturity, timely thinning would perceptibly increase the yield per acre by furnishing useful material which would otherwise decay in the woods and add to the danger from insects and fires. If, however, the cutting of pole ties were limited to trees removed in thinnings, a qualified person would be required to mark every tree which should be cut, and that could be profitably done only by owners of large forest tracts.

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[a] "The Decay of Timber and Methods of Preventing it," by Herman von Schrenk, Bulletin No. 14, Bureau of Plant Industry, U. S. Department of Agriculture, p. 22.

The following table, taken from Bureau of Forestry Bulletin No. 53, Chestnut in Southern Maryland, shows the total length of material wasted in tops of trees cut for hewn ties.

Diameter breast-high.	Volume.	Length wasted.	Diameter breast-high.	Volume.	Length wasted.
Inches.	*Ties.*	*Feet.*	*Inches.*	*Ties.*	*Feet.*
10	1	51	16	5	41
11	2	48	17	5	43
12	3	44	18	5	45
13	3	49	19	5	47
14	4	43	20	5	49
15	4	46			

The waste of timber which attends the cutting, as shown in the table, is very great, but the demand for chestnut tops for other purposes is comparatively small.

STAVES.

In a report on the tight-cooperage industry Mr. H. M. Hale, of the Forest Service, states that the greatest waste in tight cooperage occurs in the manufacture of split staves. He further states that by far the greater number of export staves at the present time are split. In 1897, 51,120,171 staves were exported. The manufacture of staves by splitting is particularly wasteful, since only butt logs and particularly straight-grained sticks—or, in other words, the highest class of timber—can be used.

The following table of measurements taken in Kentucky shows the diameter breast-high and the top diameter to which white-oak trees were used for split staves:

Diameter breast-high.	Top diameter.	Diameter breast-high.	Top diameter.
Inches.	*Inches.*	*Inches.*	*Inches.*
16	15.1	27	20.7
17	15.5	28	21.4
18	15.9	29	22.0
19	16.3	30	22.7
20	16.7	31	23.3
21	17.2	32	24.0
22	17.7	33	24.7
23	18.3	34	25.3
24	18.9	35	26.0
25	19.5	36	26.7
26	20.1		

It will be seen from this table that the top diameter varies from 15.1 inches in a 16-inch tree to 26.7 inches in a 36-inch tree. It is obvious that the amount of waste, especially in large trees, is very great.

The following facts are taken from a report on Woods for Slack Cooperage and Their Economic Utilization, by J. J. Levison, of the Forest Service. In the manufacture of slack cooperage under present methods it is absolutely necessary to use green timber. Even after green timber is cut it is frequently allowed to lie in the woods so long that it becomes too dry or too checked for cooperage purposes. As in the case of saw logs, heading blocks are frequently cut too long. Mr. Levison states that blocks are frequently cut to the length of 21 inches, when only 17½ or 15-inch heading will be cut from them. Logs intended for staves are cut in the woods to lengths which are multiples of 32 inches, because of poor judgment in the workman or wood superintendent, and it is often found necessary to utilize at the mill for heading, material which was cut in the woods for staves. In logs which were cut for 6-stave lengths the waste, if it is found necessary to utilize the log for heading, is 3 inches to the log. If, on the other hand, the log was cut for 5-stave lengths, the waste, if it is necessary to utilize this for heading, is 13 inches. Not infrequently, through carelessness of workmen, logs are cut too short in the woods and the last block must be thrown out at the mill. As in other industries, it is necessary to combine several industries in order to secure complete utilization. For instance, in the manufacture of slack cooperage materials (heading, stave, and hoop mills) logs that will not make good hoops will freguently make good staves, and logs which are not suitable for staves will often make very good heading.

The following is an extract from The National Cooper Journal, of November, 1905, on the question of waste in the cooperage industry:

> Here in the veneer mill the man at the drag saw must cut his blocks longer than the veneer to be made from them, so that there may be plenty of room to use score knives and true up the end. Sometimes we work this very closely, and get it down to 2 or 3 inches, and then again there are times when there are from 2 to 4 inches on each end, making a total waste of 6 inches. After marking off the log, then there is a chance that the drag sawyer may have to cut off one end anywhere from 3 inches to a foot of log, and that goes into the waste pile.

POLES.

Operations which have in view only the exploitation of poles, as previously indicated, result in considerable damage to the remaining timber in the stand. In the West and Northwest very frequently it is thought to be necessary to cut very high stumps in order to remove large butts which would make the pole difficult to handle. The actual waste from the practice of long butting alone probably amounts to an average of 5 per cent or more of the material actually obtained. Another cause of waste is the necessity in many cases for cutting to specification.

VENEER STOCK.

The waste in cutting material for veneer stock is very similar to that in hard-wood saw-timber operations in the East. Obviously, however, only clear material can be used to good advantage, and specifications usually provide for diameters larger than 16 inches. Unless knotty logs and those smaller than 16 inches can be used for saw timber and other purposes, and very frequently this is not the case, such material is a total waste.

MINE TIMBERS.

The following extract from Circular No. 118 contains an estimate of the amount of waste in cutting mine timber in the southern Appalachians:

> In logging for mining timbers under present methods fully 40 per cent of the timber handled is wasted. The chief items of waste are high stumps, tops, partially used bolts, and even whole trees, which are felled and rejected because slightly twisted in grain. Of the different timbers used by the mines, the greatest demand upon the forest is for props, which are 3 or 4 inches square by from 4 to 9 feet in length, and for tram ties. Under such conditions clean logging and fullest utilization of the tops to a diameter of 4 inches should present no difficulty, if proper supervision is given to logging operations. To secure close utilization of timber it would be best to saw into the required sizes the rougher material from the tops, as well as the entire stems of those species which are difficult to split, instead of following the present practice of splitting the timber into props and rejecting all logs that will not split readily. If mining timber is cut into bolts of the required lengths in the woods, it can be sawed at the mines to the required sizes at a great saving over the present wasteful methods of manufacture by splitting.

CORD WOOD.

The great bulk of cord wood which is cut in the East at the present time is used for fuel, and a very large percentage of the total amount cut is taken from farmers' wood lots. It is almost the universal practice to cut the best trees for this purpose, since they can be cut and split much more easily than the poorer trees and the poorer species. When it is considered that saw timber is now selling for $5 or more per thousand feet b. m., and soft coal can be produced for from $3 to $5 a ton, the economic loss through the utilization of hard-wood material for cord wood, when it is suitable for saw timber, is very apparent.

A great amount of cord wood is wasted each year by failure on the part of lumber companies to work up cord wood even when there are good markets.

LUMBERMEN'S ESTIMATES OF WASTE.

While few lumbermen have made an effort to obtain exact data on unnecessary loss in logging operations, estimates by lumbermen and by secretaries of lumber associations are of decided interest. In order to obtain such estimates the following questions were sent to the secretaries of representative logging associations throughout the United States:

1. What is the percentage of loss in the average logging operation, or, if possible, in specific cases, through bad management, not considering the specific kinds of loss referred to in the following questions?
2. What is the percentage of loss through leaving inferior species in the woods, failure to cut trees which are partly merchantable, and leaving comparatively inaccessible bodies of timber?
3. What is the percentage of loss by leaving logs in the woods, lodged trees, the use of valuable material for roads or other construction purposes, unnecessarily high stumps, merchantable material left in tops, unnecessary lengths left for trimming, nonutilization of short-log lengths, and breakage in falling?
4. What is the indirect loss through fire and windfall which follows logging operations?

The following tabulation shows estimates submitted:

	Question—				
	1.	2.	3.	4.	
				Fire.	Windfall.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
North Carolina Pine Association	30	25	20	10	None.
Montana Larch and Pine		3	5	10	None.
National Slack Cooperage Association		[a] 5–25	[a] 2–5	[b] 5–10	None.
		[c] 12½	[c] 5–10	[d] 10–20	None.
					[b] 3–4
					[d] 2–3
Southwest Washington Lumber Manufacturers' Association.	2	25		([e])	None.
Southern Cypress Manufacturers' Association			([f])		

[a] Cooperage.
[b] Hard woods.
[c] Lumber.
[d] Soft woods.
[e] Very little.
[f] Very complete utilization.

LOSS FOR THE UNITED STATES IN 1907.

The following table attempts an application of the data on waste for various classes of material to the cut for the year ending June 30, 1907. It must be borne in mind that the percentage used can not be exact, and accordingly has been placed extremely low in order to be conservative. Logging methods, since much of the data here given were collected, have become much less wasteful, and the percentages given in the data have accordingly been considerably reduced:

Material.	Cut in year ending December 31, 1907.	Equivalent quantity.	Percentage of product unnecessarily wasted.	Waste.
Timber:		*Cubic ft.*		*Cubic ft.*
Soft woods ... feet	31,001,225,000	2,584,000,000	12½	323,000,000
Hard woods ... do	9,254,929,000	771,000,000	15	116,000,000
Shingles ... number	11,824,475,000	106,000,000	5	5,000,000
Pulp wood ... cords	3,000,000	270,000,000	7½	20,000,000
Wood distillation ... do	1,280,000	115,000,000	5	6,000,000
Hewed cross-ties ... number	118,383,000	414,000,000	25	103,000,000
Heading:				
Tight ... sets	27,693,000	9,000,000	15	1,000,000
Slack ... do	106,074,000	18,000,000	15	3,000,000
Staves:				
Tight ... number	385,232,000	32,000,000	15	5,000,000
Slack ... do	1,175,977,000	29,000,000	10	3,000,000
Poles ... do	3,500,000	35,000,000	12½	4,000,000
Veneer ... feet	348,000,000	29,000,000	25	7,000,000
Mine timber ... cubic feet	165,000,000	165,000,000	12½	21,000,000
Cord wood ... cords	100,000,000	9,000,000,000	10	900,000,000
Total		13,577,000,000		1,517,000,000

HOW FAR CAN THESE FORMS OF WASTE BE REDUCED THROUGH CONSERVATIVE LOGGING?

UTILIZATION ON NATIONAL FORESTS.

The methods followed in handling the sale and cutting of timber upon the national forests, in so far as they concern utilization and the protection of young trees and reproduction, are of decided interest, and result in most cases in a reduction to a minimum amount of the unnecessary waste.

The boundaries of sales exceeding $100 in amount in nearly all cases follow natural features, such as streams and ridges, rather than the lines of legal subdivisions. All sale areas are, therefore, natural logging units, and this cheapens exploitation, and provides for the cutting of the comparatively inaccessible as well as of the accessible timber.

All sales include the dead timber upon a tract as well as the living. All species, even though comparatively inferior and difficult to market, are included in the sale.

The clauses of a national forest timber-sale contract which relate to utilization and the protection of the valuable species are taken up in detail.

Clauses provide for the marking by forest officers of all live timber that will be cut, and for a penalty of double stumpage rates for all unmarked living trees which are cut and all marked trees which are left. This enables forest officers to control absolutely the cutting of trees which, for the good of the forest, it is desired to remove, and retain those which, for the protection of the forest and the provision for a second cut, it is desirable to retain.

A clause names approximate minimum diameter limits to which trees will be marked, and makes provision for the variations of these limits for the good of the forest. In order that purchasers may know the plan to be followed, sample areas are marked upon application in advance of sale. The minimum approximate limits are varied with the species to leave more and larger trees of the desirable species, in order to perpetuate them against those trees whose proportions in the stand should gradually be reduced.

Other clauses provide for payment for merchantable timber used in construction work, in order to encourage the use of inferior trees and of unmerchantable dead timber wherever feasible; for the use of saws rather than axes in order to reduce the percentage of unnecessary waste; and for the closest possible utilization in the stumps and tops. These clauses are still further strengthened by a provision for a double stumpage charge for material wasted.

Another clause binds purchasers to the protection of young trees and those which are to be left, and provides penalties for careless work.

Provision is also made for brush disposal in such a manner as to reduce the fire menace to a minimum, or make the best provision for reproduction; and for a fire-fighting force to be at the call of the local officers of the Service.

Still other clauses provide for an overrun in logs, and a penalty charge if the overrun is exceeded; and require the purchaser to pay for material suitable for saw timber at saw-timber rates, thus guarding against the use of saw-timber material for cordwood.

All national forest timber-sale contracts require the utilization of all possible material under existing conditions.

One sale in western Montana includes saw timber, mining stulls, converter poles, lagging poles, and cord wood, and utilizes all merchantable material which the purchaser is allowed to remove, to a diameter of 3 inches.

That lumbermen are purchasing timber under these restrictions and are making a profit from their operations is conclusive proof that much of the waste in the ordinary cutting is absolutely unnecessary.

ILLUSTRATIONS FROM PRIVATE OPERATIONS.

The following extract from Forest Service Circular 131, by Mr. Austin Cary, shows what may be done by complete inspection to reduce the unnecessary waste in logging. The plan would apply equally to practically all kinds of logging operations on private lands:

> Windfalls and dead standing timber are common in the virgin spruce woods of New England, and come under this head (cases in which the required utilization can not be definitely defined). The trees are often defective, and are more expensive to haul than live timber, but with present lumber prices it means a distinct loss to the owner if such material is left on the ground. At the expense of a good deal of labor thrown away in testing, this class of timber was carefully picked up. In just such a case as this, where expense has constantly to be balanced with availability at the mill, was shown the utility of inspection. A thoroughly posted man was on the ground every two or three weeks during the logging season to explain requirements, settle doubtful points, and keep things up to tone. That this paid for itself was perfectly evident. If ordinary logging was costing $4 per thousand, it might cost half as much more to pick up the windfalls and dry timber, a fact which told in the average cost of the whole cut. And yet at that figure there was a margin on even low-grade lumber, while much of the material gained was as good as the best. As a matter of fact, the rate of profit on all this class of stuff was larger than that on the main ouput of many other industries, while the amount saved the company would have made a handsome business for many lumbermen.

Below is a copy of the inspector's report as used by the Berlin Mills Company from Forest Conditions in Maine in 1902:

Camp of------------------------------, township------------------------------
Date --
Date of last inspection--
Force --
How employed --
Banked or yarded to date---
Number of crews cutting--
Stumps (if unsatisfactory specify number and crew)----------------------
Tops (if unsatisfactory specify number and crews)-----------------------
Length of logs--
Are they carefully butted and trimmed?-------------------------------
Dead and down timber---
Fir--
Are any logs, poles, or lodges left?----------------------------------
Remarks ---
Plan of cutting (marking, size limit, clean cutting, etc.)------------------
How adhered to?--
By whom are roads located?---------------------------------------
Is soft wood cut for skids and bedding?------------------------------
Is care exercised to protect small growth?----------------------------
Remarks ---
Are all logs marked and stamped?-----------------------------------
Two sledding --
Landings --

(Signed) ——— ———.

> This inspection report represents the most effective control which we have been able to exert on our logging bosses and contractors. The work of each camp is inspected once every three weeks, and the past winter all the roads cut by the crew in the interval were gone over by the inspector, looking carefully after each item of waste. By this means foremen have been stimulated to look more carefully after this work than ever before, and in respect to

economy at least, loss of stuff left in the woods, greatly improved results have been obtained.

* * * * * * *

Below is a summary of the waste discovered in the work of six camps which were under the inspection of the writer during the winter of 1901-2. In explanation it will be necessary to append the following: By poles are meant small sticks scaling 20 feet or less, b. m., and down to about 7 inches on the stump. Under down and uprooting trees is put everything of that description seen on the ground cut over. In some cases these trees lay so hard no man would go after them; in others they may have been easy to get. The two classes can not be distinguished here. The waste in stumps and tops is a matter of judgment in which the inspector might be a good deal off, as no very extended studies or computations were made in the matter. Where a man kept his work as close to orders as could with reason be expected, no charge was made against him. Stumps were to be cut down to the swell of the roots and shoveled out if the snow was deep enough to require it. It was meant that no tops should be cut larger than 6 inches, and by far the most were much less.

This table shows the merchantable timber left to waste by six Berlin Mills Company's camps under close inspection:

Camp.	Total lumber cut.	Waste in stumps and tops.	Logs and trees cut and left.	Poles.	Lodged trees.	Standing dry timber.	Down and uprooting trees.	Sure to blow down.	Total.	Percentage of cut.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
No. 1	2,000,000	....	1,000	100	....	500	6,300	4,200	12,100	0.6 of 1
No. 2	2,400,000	11,600	2,300	1,400	200	6,500	10,500	7,500	40,000	1.7
No. 3	3,400,000	35,000	5,400	6,000	6,000	3,500	27,000	17,100	100,000	3
No. 4	3,400,000	1,400	1,900	2,000	1,100	1,000	10,600	4,000	22,000	0.65 of 1
No. 5	2,500,000	30,500	2,200	5,500	2,000	4,200	10,300	6,000	61,000	2.3
No. 6	1,900,000	3,000	100	300	1,200	3,000	4,600	2,800	15,000	0.8 of 1

Total waste in 15,600,000 feet cut, 250,000, or 1.47 per cent. That can and will be improved upon, but still there are logging concerns in the State which waste twenty times as much in proportion.

The term "sure to blow down," as applied to stuff left by the loggers, explains itself. In most of the operations it was not meant to strip the land, but to leave the smaller timber to grow, where it could be safely done. Whether it will be safe is, of course, a matter of judgment. In inspecting I meant to be conservative, noting only what any experienced man, if he gave his mind to it, would feel sure was doomed to fall. I expect there will be more loss by wind in the future than is here included. Of course, it is understood that I do not claim to have seen all the waste that occurred. Some of it was covered up by brush and tops so that no man could get it all.

The following data show the comparative amount of waste in cutting stumps in two logging operations in the Adirondacks in which conditions were very nearly the same, and show very conclusively that under a system of inspection the waste in logging can be reduced. The data are taken from the preliminary working plan for Adirondacks lands belonging to the Hon. William C. Whitney, by H. S. Graves, 1899:

Average height of stumps cut at Santa Clara in 1898, and at Nehasane, N. Y., in 1897.

Diameter of trees.	Average height of stumps.	
	Santa Clara.	Nehasane.
Inches.	*Inches.*	*Inches.*
9	17	26
10	18	25
11	19	26
12	20	29

COMBINATIONS OF WOOD-USING PLANTS.

One of the most promising methods of securing complete utilization is through a proper combination of different kinds of wood-using plants. The national forest sale previously mentioned serves as an excellent illustration of such a combination. Sticks not less than 6 inches in diameter at the small end and not less than 12 feet in length, which are sound enough for mining timber or lumber, are cut into mining stulls or are used for saw timber. Converter poles are from 3 to 5 inches in diameter, and at least 20 feet long; logging poles are from 2 to 4 inches in diameter, and 12 or 16 feet long. All material, dead and living, to 3 inches in diameter, not suitable for the purposes mentioned, is utilized for cord wood.

A combination of sawmill and box factory provides for a most complete utilization, since top logs to a small diameter and exceedingly short logs, if transportation facilities are such that they can be brought to the mill, can be used profitably, and grades unsuitable for lumber make excellent box boards.

Sawmills and pulp mills are frequently combined to good advantage in the North and Northeast. The sawmill uses the large logs and the pulp mill the small logs and the slabs from the sawmill. Very frequently, where market conditions and transportation facilities warrant, it is possible to utilize material which is not suitable for saw timber, mining timber, etc., for cord wood.

The mixed hardwood forests of the East are composed of so many species especially adapted to different uses that complete utilization may be secured best by the operation of several plants. If combinations could be made of sawmill, cooperage, box, veneering, and turning plants, and waste of various forms could be used as cord wood, unnecessary waste in the hardwood region could largely be disposed of. Obviously, complete combinations of this kind are not everywhere feasible, but partial combinations would greatly improve present conditions.

The most powerful factor in securing complete utilization will be higher prices for the manufactured product. While the value and importance of various economies will be recognized by lumbermen, not until the scarcity of timber reflected in high prices makes it absolutely necessary for every concern which operates to utilize completely all merchantable material, will lumbermen practice strict economy of the forest resources on their timber lands. The statement is proved by conditions in European countries to-day. Utilization is complete in those countries where prices are high. Where prices are low, for instance in northern Norway, utilization is not more complete than in the United States.

The quotation from Forest Service Circular No. 131, shows the profit in one case from the utilization of inferior materials and close cutting in tops and stumps; and in other cases where only utilization and not the perpetuation of the forest is being considered there is no excuse, when the visible supply and demand in the United States is considered, for failure on the part of an operator to remove all material which can be disposed of at a profit.

In an article in the American Lumberman on "Waste and economy in handling North Carolina pine," Mr. George W. Roper states that factories are not allowed to ship as merchantable lumber in the rough any pieces shorter than 10 feet, and further states that the pieces of this length are limited to a certain percentage. Mr. Roper states that mills should sell No. 1 and No. 2 strips to a minimum length of 4 feet, and that pieces of both even and odd lengths, that is, 4, 5, 6, 7, and 8 feet, etc., should be placed on the market.

When the markets become such that short and odd lengths are salable and sawmill machinery is so adjusted as to allow the sawing of short logs, it is bound to result in much less waste in the woods.

Though apparently insignificant, the scale rule is responsible for much waste. In some cases a short log with a large diameter actually scales more than if the same log had been cut longer, but with a smaller top diameter, although the latter actually contains more lumber. So long as this condition lasts, it will be exceedingly difficult to require contract loggers, for instance, to log without waste.

PROTECTION OF REPRODUCTION.

Not until lumbermen believe that provision should be made for a second cut, and that forestry can be practiced on private lands at a profit, will the protection of reproduction in the logging operation itself and through the proper disposal of slash be seriously considered. The most reliable estimate which it is possible to obtain at the present time shows that the available supply of timber at the present rate of cutting will be practically exhausted in from twenty to thirty years. If lumbermen can be shown that by modifying present methods of cutting it is possible to provide for a second and clean cut within some such reasonable time as thirty years, not only will the economic gain to the country be incalculable, but what concerns the lumberman more, the vital and financial returns from the first cutting will not be greatly lessened because of more complete utilization, and at the same time provision will be made for large future returns. The cost of such management will be the possible initial increased cost of logging, and possibly reduction in present returns, the cost of technical management, and finally the cost of patrol and taxes. Taxes on cut-over lands, while probably excessive in most States at present, will without doubt be reduced to a just basis when the States fully understand the necessity of providing by judicious taxation for a future timber supply.

SUMMARY.

Data collected by men who are thoroughly familiar with market conditions and the possibilities in the utilization of timber show that at the present time in the United States there is much unnecessary waste in logging. This fact is also acknowledged by lumbermen. This unnecessary waste occurs because of conditions, or prejudice, or various kinds of bad management resulting in—

Poorly conceived and poorly executed logging plans.

Failure to remove from the woods merchantable material which is actually cut.

Failure to cut and remove inferior trees, partly defective trees, and inferior species which are merchantable.

Failure to remove small bodies of timber in comparatively inaccessible places on which the profit is low.

The removal of only one class of material from the forest when others are present and merchantable.

Failure to utilize merchantable dead timber.

When inferior trees and inferior species are available, the use for construction work of valuable species and valuable trees which can not be otherwise utilized at a later time.

Failure to use materials for the purposes to which they are best suited.

The cutting of trees for tan bark only, and waste of the logs.

The cutting of unnecessarily high stumps.

Failure to utilize all of the merchantable material in tops suitable for saw timber or cord wood or other use.

Failure in requiring the proper variation in log lengths.

The nonuse of odd and short log lengths.

Unnecessarily long trimming lengths.

Unnecessary breakage in felling and transportation.

Too great loss in driving; and

Careless use of logging machinery such as donkey engines.

In addition, through economic conditions such as taxes, low prices for manufactured products, ignorance and disregard of the value of young trees and reproduction, and the necessity of providing for future crops, the possibilities of future timber supplies have been greatly reduced, and the time for producing such supplies greatly extended through unnecessary damage to reproduction and young trees in logging operations, and the fires which follow logging operations in many cases because of failure to dispose properly of the slash resulting from the cutting.

Experience has shown that unnecessary logging waste on private lands may be reduced to less than 1.5 per cent by a proper form of inspection which, in modified forms, is fully applicable to all cutting on private lands.

Unnecessary waste in national forest cuttings through carefully prepared contracts and frequent inspection is not greater than 1.5 per cent on the average and in many sales the amount is negligible.

Suitable combinations of different kinds of wood-using plants can bring about a great reduction in unnecessary logging waste.

Increasing market prices without other influence will gradually bring about complete financial utilization, since lumbermen who log carelessly will not in the long run be able to compete successfully with lumbermen who utilize as fully as conditions will allow the products of the forest. This condition may, however, be greatly hastened by the means suggested.

The proper protection of the reproduction and of young trees in logging operations and the disposal of slash in such a manner as to reduce the fire menace in cut-over areas to a minimum will not be considered by lumbermen until the feasibility of conservative forest management has been demonstrated to them.

WASTE IN MILLING.

By Louis Margolin,
United States Forest Service.

SUMMARY.

WASTE IN MILLING.

In converting logs to lumber there is entailed a heavy waste. This waste may be necessary or unnecessary, and it may entail a total loss or only a relative loss.

Under present methods of manufacture the principal sources of waste are as follows:

1. Loss of bark; 10 to 20 per cent of the total volume of the log, with an approximate average loss of over 13 per cent. (See Table 3.)
2. Loss due to kerf; 15.5 per cent of the volume of the peeled log, or 13.5 per cent of the total volume of the log.
3. Loss due to edging and trimming; 10 per cent of the volume of the peeled log, or 8.7 per cent of the total volume. (See Table 2.)
4. Loss due to slabs; 10 per cent of the peeled volume, or 8.7 per cent of the total volume of the log. (See Table 2.)
5. Loss due to careless manufacture and accidents (not included in the above); 4 per cent of the peeled volume, or 3.5 per cent of the total volume of the log.
6. Loss due to standardizing lengths and widths of boards; 2 per cent of peeled volume, or 1.7 per cent of total volume.

The total loss from all sources is 49.1 per cent of the total volume of the log, and each cubic foot of log with bark yields, therefore, on an average 6.1 board feet of lumber.[a]

To manufacture the 40,250,000,000 feet of lumber produced in 1907 required 6,600,000,000 cubic feet of wood.

A portion of the waste is necessary and can not be avoided, but a large percentage can be saved in the following ways:

1. By the general adoption of thin saws—band saws and resaws.

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[a] It may be of interest to compare this figure with the two standard log rules—the Doyle and the Scribner.

The average size of log cut in the United States is probably about 18 inches in diameter at the small end. Allowing a taper of 1 inch to 8 feet, the total volume of a log 16 feet long and 18 inches in diameter, peeled, is 31.5 cubic feet. The total volume of such a log, including the bark, is 36.21 cubic feet.

A log 16 feet long and 18 inches in diameter scales, according to the Doyle rule, 196 board feet, or 5.4 board feet per cubic foot of unpeeled log. The same log, by the Scribner rule, scales 213 feet, or 5.9 board feet per cubic foot of unpeeled log.

2. By the elimination of gang saws.
3. By manufacturing in round-edged or "wany" form a large part of the lumber which is to be worked over.
4. By modifying market requirements and usage so as to allow boards of random widths and odd lengths.
5. By admitting short and narrow boards.
6. By modifying standard grading rules to allow defects on ends and edges without seriously reducing the grade of a board.
7. By more careful manufacture and more perfect machinery.
8. By utilizing short boards, slabs, and waste for such articles as matches, toothpicks, excelsior, novelties, and other purposes for which large boards and planks are now used.

Under present economic conditions and until more perfect machinery is devised the following wastes are considered unavoidable:

1. Practically the entire bark (except what may be used in tannin)—13 per cent of the total volume of the log.
2. Kerf—10 per cent of the total volume.
3. Loss from edging and trimming—5 per cent of total volume.
4. Loss from slabs—5 per cent of total volume.
5. An additional 1 per cent for unavoidable accidents.

Total necessary waste, 34 per cent of total volume of log, which leaves an unnecessary waste incurred under present methods of over 15 per cent of the total volume. In other words, over 30 per cent of the present waste is unnecessary and can be avoided.

Part of the waste is relative, but it is roughly estimated that the part utilized represents only 8 to 9 per cent of the value of the lumber which the waste represents.

WASTE IN MANUFACTURE OF VENEER.

The main sources of waste in the manufacture of veneer are as follows:

1. Trimming defective ends—3.5 per cent.
2. Loss through checks and cracks—6 per cent.
3. Loss through damaged sap—3.2 per cent.
4. Loss of cores—3.1 per cent.
5. Loss through breakage—5 per cent.
6. Loss through imperfect drying—4 per cent.

The total from sources mentioned is 24.8 per cent of the lumber manufactured.

In addition there is a loss of at least 5.2 per cent from miscellaneous sources, such as kerf in sawed veneer, carelessness, miscut veneer, etc., bringing the total loss up to about 30 per cent. This is equivalent to a loss of over 100,000,000 feet of the 348,000,000 feet manufactured into veneer in 1907.

WASTE IN MANUFACTURE OF COOPERAGE.

The main sources of loss in the manufacture of cooperage are:

1. Allowing logs to dry and check in the woods.
2. Cutting logs into bolts and allowing an overrun of one or more inches in the length of each bolt—7.7 per cent.
3. Improper bolting and the conversion of bolts into staves.
4. Carelessness in stave jointing.

5. Seasoning the finished product—about 4 per cent.

Although no detailed figures for the loss incurred through each of the above sources are available, yet it is estimated to be 40 to 50 per cent of the sound lumber, or, assuming an average of 45 per cent, 56,250,000 board feet on the 1,250,000,000 board feet used for cooperage stock in 1907.

The method of reducing the loss is through greater care in the various processes of manufacture, better and more highly specialized machinery, and a more thorough utilization of the waste.

An attempt has been made in this paper to point out the usual source of waste in converting logs into lumber. At least a part of this waste is shown to be unnecessary. Most of the waste is due to the low value of lumber when compared with other factors of production, such as cost of labor, freight rates, etc. With the growing scarcity of wood and its consequent rise in value ways will be devised for reducing the waste. As long as it is not possible for the Government to exercise a control over the use and misuse of the natural resources, an unnecessarily heavy waste may be expected all along the line.

WASTES AND LOSSES IN MILLING.

INTRODUCTION.

In converting trees to usable shape and form, whether the form be firewood, boards and plank, dowels, or veneer, there is entailed a certain amount of waste, which varies mainly with the form of the product and the value of the wood.

Loss and waste should be distinguished. Loss occurs when material is sacrificed because it can not be used with profit. Waste occurs when only a part of the possible marketable product is extracted; it may be due either to carelessness or ignorance.

This paper will consider the wastes and losses involved in milling. It will consider the log from the beginning, carry it through the various processes in the mill, and show the waste at each operation. In addition, a brief description will be given of the waste connected with the converting of logs into cooperage and veneer stock.

The figures used are taken mainly from two sources. The first of these are mill tallies made by the Forest Service in various regions for the purpose of determining the amount and grades of lumber cut from different sized trees; in connection with this work some 40,000 logs of a dozen different species were measured in the woods and followed through the mill. As to the second source, circular letters were sent to 2,000 of the leading mill men in the country; replies were received from 540 manufacturers whose operations represent an annual cut of 7,121,000,000 board feet. In addition, a circular letter was also sent to 800 cooperage and 250 veneer makers.

Very often wastes can not be expressed in exact figures. The waste due to careless handling of the "nigger" or to the reduction of the grade of lumber caused by careless sawing is of this kind. In such cases care was taken to estimate the waste as accurately and conservatively as possible.

VARIOUS PROCESSES IN A TYPICAL MILL.

It may not be out of place here to give a brief description of the various processes through which a log passes in a typical mill. On reaching the log deck the log is put on the carriage by means of "kickers" and "loaders." It is turned on the carriage by means of a long iron pole fitted with sharp hooks known as the "nigger." As each slab is sawed off the log is pushed forward toward the saw by means of a "setter." The slab is separated from the log by the "off-bearer" and is sent on to the "edger" where the waney edges are sawed off and the edged board goes on to the "trimmer," which cuts or trims off the ends and reduces the boards to a standard length. The boards are then "inspected" or graded and sent to the lumber yard where they are stacked and seasoned, either in the open air or in a dry kiln. Almost every one of these steps involves some waste.

WASTE IN SAW KERF.

One of the chief wastes in converting logs into lumber is saw kerf. This waste varies with the thickness and gage of the saw and the care with which the sawteeth are swaged. It varies also with the thickness of the lumber—the thicker the lumber the less being the amount of kerf in proportion to the size of the log.

The two most common forms of saws used in the United States are the circular saw of 8-gage thickness, swaged to cut about one-fourth inch kerf, and the band saw of 14 to 16 gage thickness, swaged to cut about one-eighth inch kerf. Most of the larger mills are now using the band saw, whereas the smaller mills, especially those that are portable, are equipped with circular saws. There are a great many more circular-saw mills in operation than band-saw mills, but the amount of lumber cut by the two classes of saws is probably the same. The average kerf may, therefore, be assumed to be three-sixteenths of an inch.

An idea of the enormous waste in kerf may be obtained from the following figures: The total production of lumber in the United States during 1907 was approximately 40,250,000,000 feet. The kerf on this lumber, assuming that all of it was cut into 1-inch boards, is equivalent to over 7,500,000,000 feet. To obtain this amount of lumber it would be necessary to cut over an area of about 1,250,000 acres of forest, running 6,000 board feet to the acre, an area almost as great as that of the entire State of Delaware. Figuring that the average annual growth of lumber is 300 board feet per well-stocked acre—a most liberal assumption—the annual loss due to kerf represents the yearly growth of forest on 25,000,000 acres, an area equal to that of either Virginia or Kentucky. That is, if either of these States were covered with an unbroken growth of timber, the annual growth in such a forest would be just enough to compensate for the sawdust.

Since sawdust is, in most cases, used to furnish the fuel to run the mill, it is not an absolute loss. However, with the modern fuel-saving burners the supply usually is in excess of the requirements of the mill. Besides, it is poor economy to convert good lumber into sawdust, even if it is used for fuel, and any saving of waste from this source is greatly to be desired. In a few cases, also, a small portion of the sawdust is sold for packing, stable flooring, etc. It will now be shown that part of this waste is unnecessary and quite avoidable.

The kerf really consists of two parts—the actual width of the sawteeth and the swage of the saw. As mentioned above, the average circular saw used for sawing logs is 8-gage. This represents a thickness of 0.165 of an inch. The actual kerf for such a saw is 0.25 of an inch, the extra 0.085 of an inch being due to "setting" the saw in such a way that it will allow for a proper "clearing" of the log—in other words, to allow space in the cut for the sawdust, and prevent the blade of the saw from binding against the cut surface. Similarly a band saw of 14 to 16 inch gage, representing a thickness of 0.072 of an inch, cuts a kerf of 0.125, an allowance of 0.053 of an inch for "clearing" the log. At least part of this allowance is quite unnecessary. The saving in lumber which may be effected through careful filing and setting is considerable. It probably represents no less than 0.03 of an inch in each cut, or about 3 per cent of the lumber cut.

Unnecessarily thick saws make unnecessary waste in kerf. This brings up the much discussed question of the relative merits of the band and the circular saws.

The claims that have long been put forward in support of the circular saw are that it can be fed faster, that it requires less power, that it is more easily set up and kept in order, and that it does not need the skillful attention required by the band saw. Recent investigations show that these claims have been greatly exaggerated; in fact, that some of them are baseless. It is now generally conceded that in large logs the band saw will cut more lumber in a given time than will the circular, and that the band saw uses less power than the circular saw, doing the same work.

The main point, however, in favor of the band saw is the great saving in lumber which it makes possible. The following table, based on a mill tally of 5,177 white-pine logs cut with a circular saw and 767 white-pine logs cut with a band saw, shows the number of board feet of lumber obtained per cubic foot of peeled log. The lumber was not edged, but was sold "waney" or round edged.

TABLE 1.—*Board feet per cubic foot of peeled log (round-edged lumber).*

Diameter inside bark at small end of log.	Cut with a circular saw.	Cut with a band saw.	Diameter inside bark at small end of log.	Cut with a circular saw.	Cut with a band saw.
Inches.	*Board feet.*	*Board feet.*	*Inches.*	*Board feet.*	*Board feet.*
5	5.5	6.5	13	7.4	8.5
6	6.0	6.6	14	7.5	8.6
7	6.4	6.6	15	7.5	8.6
8	6.7	6.8	16	7.5	8.6
9	6.8	7.3	17	7.6	8.8
10	6.8	7.5	18	7.7	9.0
11	6.9	7.8	19	7.7	9.0
12	7.2	8.2	20	7.8	9.1

The conditions in the mills where the lumber was tallied, on which the above table is based, were very similar, and the difference between the relative amounts of lumber obtained is due almost entirely to the difference between the thickness of the saws.

The saving effected by the band over the circular saw is usually estimated by lumbermen to be 10 per cent of the possible lumber cut. Assuming, as before, that one-half of the 40,000,000,000 feet of lumber produced last year was cut with a circular saw, the saving of 10 per cent would represent a saving of 2,250,000,000 feet (the 20,000,000,000 feet representing only 90 per cent of the amount of lumber obtainable), or the annual growth on over 6,500,000 acres of forest at 300 board feet per acre.

In addition to the loss caused by an undue amount of sawdust, the circular saw entails a loss from another source. The width of the widest board which such a circular saw can cut is equal to the radius of the saw, less about 3 inches (allowed for the collar of the saw). For this reason, even where a 54-inch saw is used, no log greater than 24 inches in diameter can economically be cut with it. When a larger log comes into the mill it is turned on the carriage and slab after slab is pared away until the log becomes small enough for the saw to cut through it completely. This involves not only an enormous waste of the best lumber in the log, but also a great waste in labor. In many instances the plank or slab is only partly separated from the log, and axes are used to cut it off completely.

Measurements made in a mill cutting western yellow pine in New Mexico indicate that the loss of lumber from the use of circular saws too small for the large logs was from 3 to 5 per cent of the entire output of that mill. The loss in value was even greater, since the wood wasted is the clearest lumber in the log. An idea of the time loss may be obtained from the following instance: A log 36 inches in diameter came into the mill. It was figured that under favorable conditions it should have taken from twelve to fifteen minutes to saw it up. The actual time consumed from the time the log was put on the carriage until the last board was taken away by the off-bearer was a little over forty minutes, a loss of at least twenty-five minutes, and for more than an hour afterwards the mill was littered with slabs and chips, and smooth, efficient work was prevented. No definite figures of the loss from this source can be given for the entire country.

Prof. C. A. Schenck arrives at the following conclusions in regard to the relative merits of the band and the circular saws:

> The superiority of the band over the circular saw lies in a saving of 1,000 board feet in every 16,000 feet of -inch boards obtained. The boards have a better width. Logs over 4 feet through can not be handled by circular saws. Further, the band saw allows of a more rapid feed.

The band saw has come into general use in the bigger mills, but the vast majority of mills cutting less than 2,000,000 to 4,000,000 feet a year—in other words, the majority of the small and portable sawmills—are still using the thick circular saws. The main reason for this fact is that it is easier and cheaper to equip a mill with circular saws than with band saws.

The additional waste due to thick saws takes place at the mill, and the loss represents not only a loss in the cost of stumpage, but also a loss in logging and bringing the logs to the mill. In short, it is not only a waste of lumber, but also a waste of labor. With these facts in view, it is only a short time before the band saw will replace the circular saw in all but the very smallest operations.

Mr. Austin Cary, who has been investigating the practicability of the use of portable band-saw mills, has the following to say on this subject:

> The saving in lumber secured by the use of band saws in place of the thicker rotaries is well known. It is usually reckoned by lumber operators as 10 per cent of the cut.

The band saw from the operating point of view is also satisfactory and effective. It uses less power than a rotary doing the same work. It does true and satisfactory sawing if set up right, not overspeeded, and properly handled. As a stationary mill it is for many purposes considered the best and it is securing something of a field in use as a portable. The chief difficulties in its use arise in connection with keeping the saws in order. Much more skill and equipment are required than in the case of the rotary.

Light band mills are employed as portables to some extent in New England and in the South. This paper is written with a view to their use in the western forests.

A type of mill in use for this purpose at the present time carries saws 8 inches wide and 33 feet long, of 16 or 18 gauge thickness, swaged to cut three-thirty-seconds inch or less. The wheels are 5 to 5½ feet in diameter, the upper one adjusted to maintain an even tension at all times. The saw frame entire weighs in different makes from 6,000 to 10,000 pounds, but in transportation is practically taken apart, so that the weight of the heaviest single piece is only about 2,000.

Firm setting is essential to cheap and smooth running and the production of well-sawed lumber. This may commonly be secured by means of posts set in the ground to which the timbers of the mill frame are fastened. If this does not in any case give sufficient firmness, the frame may be further fixed by bracing timbers rising from the ground or timber frame to a bearing on either side at the level of the upper journals.

The carriage and accessories for a mill of this type are very nearly the same as for a rotary used as a portable, an offset to free the saw from the log in gigging back being the only difference. The mill is furnished at the factory with carriage complete up to 20 feet long, set works, friction and cable feed, standard track and wheels, set shaft, and receder for about $1,600. This is about twice the cost of the same equipment for a rotary. An equipment of 6 saws costs $240.

CAPACITY AND POWER.

This mill can cut up to 25,000 feet a day, but run as a portable 10,000 to 15,000 may be counted as its capacity, according to quality of logs. To run such a mill on pine logs, engine capacity of 35 horsepower net is found to be sufficient. An edger requires 10 horsepower additional and a wide planer 25. A 50 horsepower engine of good make with boiler of one-third greater capacity costs in the neighborhood of $1,200. With large logs considerably less power is required to cut the same amount of lumber with the band than with the rotary. With small logs, the rotary requires less power.

FILING ROOM.

It is customary when using the band as a portable to construct a small shanty for filing near the mill, with steam pipe from the main boiler running a small filing-room engine. Where the mill is longer in one place the filing room may be built in the roof of the mill and the machinery run from its shafting. The equipment required is as follows: Automatic saw sharpener, stretcher, adjustable stand and pulleys, filing clamps, shears and retoother, automatic lap grinder, forge, brazing table, swage, shaper.

Total cost of these tools about $600. Total weight about 3,000 pounds. This outfit embraces all that is required to do the fitting and filing by machinery. The oufit may be lessened if certain parts of the process are done by hand.

KEEPING IN ORDER.

A good-sized outfit of saws, six being desirable, is the first requisite for successful employment of the band saw. One set of three may then be kept constantly in order and in reserve for emergencies, while the other three are in use and subjected to minor repairs. Experience and skill are both required to keep a band saw in order. Condition has to be more carefully kept up than in a rotary, though there is this advantage—that apparently bad accidents, such as would destroy entirely the value of a rotary, may be repaired on the spot in case of a band by means of the shears and retoother. Filers for band saws uniformly draw good wages, though good work here pays in quality and output of lumber. It is not necessary, however, to have a special filer for a portable band mill in most circumstances, as the sawyer may occupy this post also, making small repairs to his saws at noon or night and heavier repairs at slack times or between settings. This arrangement has been successfully worked in Massachusetts, and the running cost of operation of a band mill in consequence kept very close to that of a rotary.

TRANSPORTATION.

A band mill for portable use requires the transportation of from three to four tons more than a rotary employed in the same work. There is extra cost involved also in setting up the mill, as earlier explained. In fact, in Massachusetts practice the cost of moving a short distance and setting up is reckoned at twice that for a rotary. This enlarged cost does not hold in the same ratio on long moves, and the larger the amount of lumber to be cut at one setting, the more advantageous the band mill. For set-ups of under 500,000 the band as against the rotary can not be considered on ordinary lumber as practicable. When the amount to be cut is a million or more, the band is considered in Massachusetts advisable. On high-grade, valuable timber the saving secured by the band saw is a far more important matter and smaller set-ups can be profitably handled.

CONCLUSIONS.

The band mill cuts lumber out of anything but the smallest logs with a third less power than the rotary.

It saves 10 per cent or more of the lumber cut, whatever the value of this may be.

The initial expense of a band mill for portable use is greater than a rotary, the figures for the two outfits complete being approximately $2,500 and $4,000.

The band mill is more expensive to move and set up. This makes it impractical for very small amounts of timber.

The band mill requires more skill to keep the saws and machinery in order, but by good arrangements the extra cost of this work may be kept down very low.

Altogether the use of the portable band seems to promise considerable saving and efficiency in the utilization of the timber of the national forests.

When band saws first came into vogue and the advantage of narrow kerf was seen, efforts were made to make the saw thinner and thinner. Experience very soon showed that when the steel reached a certain degree of thinness it did not possess the rigidity necessary to cut straight lumber. But even after this limit was reached a further reduction can be made in the kerf by the introduction of the resaw.

The resaw is either a circular or, more often, a band saw of very narrow gage, and is used to resaw thick lumber cut with the heavier primary saws. There is a double saving in the use of a resaw, a saving in lumber and a saving in the labor of the highly paid sawyer. A skillful sawyer receives from $5 to $10 a day. The grade of labor commonly employed on a resaw is paid from $2.50 to $4 a day. Where a resaw is used the log is cut into thick plank by the skillful sawyer, who gets the greatest amount and the highest grades of lumber possible from the log, and the thick plank is then resawed by the lower-paid resaw man. This is an ideal arrangement, and the millmen are fast beginning to realize it. Out of a total annual cut of 7,121,000,000 feet reported from 540 mills, 4,130,000,000 feet, or 58 per cent of the total, was resawed. The percentage of lumber resawed in the entire country is, however, probably less than 58 per cent of the entire output, since the mills reporting were mainly large mills, and resaws are mostly employed in large mills.

On the other hand, possibly one-fourth of the above named lumber was cut with gang saws. The waste due to gang saws is very large because of the high percentage of lumber which is converted into slabs. The main advantage of the gang saw is the rapidity with which it works. Although no definite data are available it is safe to say that the waste in lumber offsets this gain. It takes little figuring to prove this point. Assuming that the value of the log on the carriage before it is cut is $7.50 a thousand board feet, and that the average wage is $2.50 a day per man, the money represented by a waste of only 1,000 board feet will pay the wages of 3 men for a day. With the extra waste due to the gang saw figured at 10 per cent of the actual cut, a mill with a gang capacity of 100,000 feet a day can afford to employ 30 extra men a day instead of the gang saw. It is very doubtful whether the gang saw saves that much labor.

WASTE DUE TO SLABS, EDGINGS, AND TRIMMINGS.

Probably the heaviest waste in a sawmill is in slabs, edgings, and trimmings. This waste is due to the circular form of the logs, to their surface irregularities and to their natural crook or "sweep." The amount of it depends on a number of factors:

1. The species and age of trees cut. Some species are much more cylindrical and regular in shape than others. Older trees are usually fuller and less tapering than young trees.
2. The position of the log in the tree. The top and butt logs of most species are more tapering than the middle logs.
3. The skill and care of the sawyers in the woods. Judicious division of the tree into logs will largely eliminate crooks and defects.
4. The length of the shortest board considered merchantable.
5. The value of lumber as compared with freight rates. Where lumber is comparatively cheap, while freight rates are high, there will be more slabs and short boards wasted than would otherwise be the case.
6. The care exercised by the sawyer and the other mill hands.

For convenience in describing the waste in slabbing, (1) loss in edging and trimming and (2) loss in slabs will be considered separately.

LOSS IN EDGING AND TRIMMING.

Prof. Judson F. Clark, who, while constructing his International log rule, had occasion to study the question of loss of lumber in edging, states the following conclusions:[a]

> 1. Edging waste remained practically constant regardless of the width of kerf cut by the saw.
>
> 2. It was found that the waste due to crook (major and minor) of all degrees was in direct proportion to the circumference of the logs sawn; i. e., the waste due to any particular degree of crook in a 20-inch log was practically double that caused by a similar amount of crook in a 10-inch log.
>
> 3. When provision is made in the scaling score for an average taper of 1 inch per 8 feet linear, and when the logs show an average major crook of 1½ inches per 12 feet, the necessary allowance for edging waste as above defined was found to be 0.8 foot board measure per square foot bark surface for white-pine logs of all dimensions.
>
> The effect of increasing major crook on the product of sawn lumber was also studied. The results of such a study depend directly on the size of the smallest board which is regarded as merchantable by the investigator, for with increasing crook there is a greatly increased output of short lengths sawn from

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[a] "The measurement of saw logs," by Judson F. Clark, in Forestry Quarterly, Vol. IV, No. 2, pp. 84–85.

the heavy slabs. The rules of the National Hardwood Lumber Association, the Louisiana Cypress Association, and other similar bodies have set the minimum dimensions of boards entitled to pass inspection and measurement in the case of most species at 3 inches in width by 4 feet in length. Using a minimum unit of just double this size I found that as logs were cut for ordinary commercial purposes in the mill in which I made my tests, an increase in the average major crook of 1 inch per 12 feet increased the allowance required for edging 0.1 foot board measure per square foot of bark surface. With a minimum unit of 3 inches in width by 12 feet in length the additional waste in edging for the same increase in average crook was just threefold, or 0.3 foot board measure per square foot of bark surface.

Although no more definite data than those given above are available on this subject, yet a fair idea of what this loss amounts to may be gathered from Table 2.

TABLE 2.—*Waste in slabs, edging, and trimming.*

Diameter at small end of log, inches.	Edged and trimmed yellow poplar.			Unedged and untrimmed white pine.			Per cent of peeled log wasted, presumably in edging and trimming.
	Board feet per cubic foot of peeled log.	Per cent of peeled log used.	Per cent of peeled log wasted in kerf, slabs, edging, and trimming.	Board feet per cubic foot of peeled log.	Per cent of peeled log used.	Per cent of peeled log wasted in kerf and slabs.	
10	6.6	55	45	7.5	63	37	8
11	6.7	56	44	7.8	65	35	9
12	6.7	56	44	8.2	68	32	12
13	6.7	56	44	8.5	71	29	15
14	6.9	57.5	42.5	8.6	72	28	14.5
15	6.9	57.5	42.5	8.6	72	28	14.5
16	7.1	59	41	8.6	72	28	13
17	7.1	59	41	8.8	73	27	14
18	7.3	61	39	9.0	75	25	14
19	7.3	61	39	9.0	75	25	14
20	7.4	62	38	9.1	76	24	14
25	7.6	63	37	....	....	....	....
30	7.7	64	36	....	....	....	....
35	7.8	65	35	....	....	....	....
40	7.9	66	34	....	....	....	....

The foregoing table is based on yellow poplar logs which were edged and trimmed at the mill, and on white pine logs which were neither edged nor trimmed. The logs in both cases were sawed with a band saw. The difference in the percentages of waste is presumably due to the waste incurred in edging and trimming. It is seen to vary from 8 per cent for the smaller logs, which are most wasted in slabbing, to 14 per cent in the larger logs.

Since the old yellow poplar is much more cylindrical than the second growth white pine, the loss in slabs, edging, and trimming should have been relatively less in the former than in the latter species. It is, therefore, safe to assume that the minimum waste incurred in squaring boards is 14 per cent of the peeled logs; a very conservative estimate would place it at 10 per cent. This is equivalent to a loss of about 4,500,000,000 board feet in the 40,250,000,000 board feet of lumber cut in 1907.

There is very little unedged timber sold in the United States—in all probability less than 10 per cent of the total output. Deducting 10 per cent from the 4,500,000,000 feet figured above, still leaves over

4,000,000,000 feet lost annually in edging and trimming. Assuming an annual growth of 300 board feet per acre, it would take a solid forest of 13,333,333 acres to produce the lumber wasted annually in squaring boards. This area is almost as great as the combined territory of Vermont, New Hampshire, and Connecticut.

There is no doubt that a portion of this loss is quite necessary and unavoidable, and where this is true, if the loss did not occur at the mill it would be transferred to the consumer or woodworker. Nevertheless, by far the greater portion of the waste is due to the cheapness of the wood when compared with freight rates, and to usage or custom.

A very heavy waste in the manufacture of lumber is caused by standardizing lengths and widths of boards. It is a general requirement of the lumber market that the lengths of boards shall be in multiples of 2 feet. Odd lengths, such as 9, 11, 13 feet, etc., are not admissible except in special orders. The result is that much good lumber is lost through trimming.

A piece of lumber may have a defect at one end making it a few inches shorter than a certain standard length. The board is trimmed down to the next lowest standard length, with a loss of almost 2 linear feet of board.

Similarly with the widths of boards. It is customary with certain kinds of wood, such as white pine, western yellow pine up to 16 inches in width, western larch, etc., to cut the boards in widths which are multiples of 2 inches. With other species, however, as with most of the eastern and southern hard woods random widths are admissible.

The lengths of boards can, to a large extent, be regulated by the sawyers in the woods; i. e., the sawyers can divide a tree without great loss into logs of standard lengths. But the width of boards can not be so regulated. It follows from the law of averages that in the long run the loss in width will be 1 inch when the standard widths are multiples of 2 inches, or one-half inch when the standard widths are consecutive inches. With the average board sawed 12 inches wide this loss would represent a waste of from 4⅙ to 8⅓ per cent of the lumber cut, in addition to loss incurred in edging off the wane. This waste is unnecessary and inexcusable.

What the exact loss is through this source—trimming to standard lengths and widths—it is, of course, impossible to say, but it is possible to make a rough estimate. A study of the grading rules adopted by the various lumber manufacturers' associations brings out the fact that about one-third of all the lumber manufactured is cut into standard widths. Assuming a loss of three-fourths of an inch in width, the average between a loss of 1 inch for even inch widths and one-half inch for consecutive inch widths, and an average width of board of 12 inches, the loss last year due to standardizing widths was at least 2½ per cent of the total output, or a little over 1,000,000,000 board feet of lumber. Two per cent will be taken as the working estimate.

LOSS FROM SLABS.

In addition to the loss in edging and trimming, and closely allied to it, is the waste in slabs. The factors which influence this loss have already been stated. The seventh column in Table 2 indicates the percentage of the peeled log wasted in kerf and slabs. The percentage of kerf is fairly constant for logs of different sizes, and in Table 2 amounts to 11 per cent of the volume of the peeled log.[a] Subtracting 11 from the value given in the column leaves the percentage of the volume of the peeled log converted into slabs. This is seen to vary from 26 per cent for a 10-inch log to 13 per cent for a 20-inch log, the percentage of waste decreasing as the size of the log increases. The average log sawed in the United States is probably less than 20 inches in diameter. This would indicate a minimum waste of 13 per cent in slabs alone. To be conservative this figure will be reduced to 10 per cent of the peeled log, or a total loss of 4,474,000,000 feet for the lumber produced in 1907.

This loss arises mainly from the fact that short and narrow boards can not now be utilized as lumber. In a number of mills observed in various parts of the United States the shortest board that it pays to ship is 8 feet long. The narrowest admissible width is usually 3 inches. Shorter or narrower boards are either cut as lath and batting, or else are used as fuel or burned in the slab burner.

To summarize: There is lost annually through edging and trimming about 10 per cent of the total possible output. An additional 2 per cent of the volume is lost through standardizing sizes, while at least 10 per cent more is lost through slabs, a total loss in slabs, edging and trimmings of 22 per cent.

All of this waste is not an absolute loss. A large part of the slabs and edgings is used for making lath, and in so far as the edgings and slabs are of such size and form that they can not be utilized for any better purpose, their conversion into lath should not be considered a waste at all. To put it differently, the country requires a certain number of lath. This lath can be very economically manufactured from slabs and edgings at a sawmill. As long as the slabs and edgings are more useful for lath than for any other purpose, there is no waste entailed, but a waste occurs when material better fit for lumber is converted into lath.

The production of lath in 1907 was 3,663,600 thousand pieces. It is generally assumed by lumbermen that on an average 1,000 lath can be produced for every 3,000 to 4,000 board feet of lumber manufactured. Assuming that all the lath produced in 1907 was made from slabs and edgings (and there is no doubt that a large percentage of it was cut from logs and bolts), it would have taken an output of only 14,654,400,000 board feet of lumber to yield as a by-product all the lath required by the country last year. This still leaves a waste of the edgings and slabs from over 25,500,000,000 feet of lumber, or from two-thirds of the lumber produced in 1907. A part of the waste, and probably a very small part of it, was converted into pickets and battings, but the fact still remains that about one-half of the slabs, etc., representing a potential output of over 4,500,000,000 feet of lumber was wasted. A part of it, perhaps the larger, was burned under the boilers at the mill, but its use as fuel is very small, when compared with its value as lumber, and the consequent loss entailed is heavy.

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[a] The lumber was cut with a band saw removing one-eighth inch kerf. The loss in kerf was therefore 1 inch for every 8 inches of boards sawed. This is equal to one-ninth or 11 per cent of the volume of the peeled log.

That a large portion of the waste in trimming to standard lengths is quite unnecessary may be gathered from the fact that the average length of all the pieces of lumber in the ordinary house, including timbers, flooring, sheathing, siding, finish, casings, base, doors, windows, frames, etc., but not including lath and shingles, is less than 4 feet. The average length of all lumber used for every purpose, including the building of bridges, ships, docks, railroads, fences, boxes, houses, etc., is still under 4 feet. Thus large quantities of lumber longer than the average piece used are being used for fuel, because the pieces are considered too short.[a]

Lumbermen throughout the country are fast beginning to appreciate the enormous waste which accompanies the manufacture of lumber, and there is some hope that savings will be effected all along the line. It may not be out of place to give the following extract taken from a paper read by George W. Roper, general manager of the John L. Roper Lumber Company, Norfolk, Va., before a meeting of the North Carolina Pine Association, and reported on page 40 of the American Lumberman for April 7, 1906.

> According to our present method of inspection and grading and under our general rules we are not permitted to ship as merchantable lumber in the rough pieces which are shorter than 10 feet, and are limited to a certain percentage of this length.
>
> I do not believe that the time has yet come in which we can make our merchantable lengths 12 inches and up, but I believe that we can just as well sell No. 1 and No. 2 strips 4 feet and up in length as some others can sell their product in even shorter lengths. When I say 4 feet and up, I do not mean 4, 6, 8, 10, etc., but mean lengths of 4, 5, 6, 7, 8, etc. The barbarous idea, originated by us possibly, of cutting off a board 2 feet in order to cure a 6-inch defect at the end should not, in my judgment, be longer tolerated. There is no reason in the world why the trade would not accept 11, 13, and 15 foot boards as well as 10, 12, 14, and 16. Then, again, if we were allowed to use short lengths could we not often in our woods secure an 8-foot log at the top of the tree which now is lost?
>
> I understand that, in some other classes of wood, there is a grade known as "shorts"—being lumber in lengths of from 4 to 10 feet. This lumber, I am told, is sold log run, or used to be sold that way, for about three-fourths as much as the usual log run, exclusive of the shorts. If we could adopt as our standard lengths for Nos. 1, 2, and 3 lumber 4 feet and up in multiples of 1 foot, and in box grades adopt similarly 6 feet and up, we could expect to get from our sawmills an increase output on an average from our logs sawed about 5 per cent. With a mill cutting 60,000 feet of lumber a day, situated at Tidewater, Va., and assuming the average value of the output a thousand to be $20, which is considerably under that obtained by us at present in my judgment, we would be enabled to gain $60 a day which now is lost. Assuming the mill ran two hundred and fifty days in the year there would be an actual saving of $15,000, which is 6 per cent on an investment of $250,000. If the mill plant is worth $60,000, the saving would represent 25 per cent on the plant investment or the cost of the plant.
>
> Some of our mill plants are making steam now with lumber which ought to be worth $15 a thousand, if we got no more for it than edge-box price. A great many of our mill plants are putting the clearest of their lumber into the slabs, because we do not have a rough-lumber grade which will admit short, clear boards. The clearest lumber that we get is that which is located nearest the outside of the log, and anything that we can do to reduce the merchantable lengths of No. 1 and No. 2 will not only increase the quantity of lumber that we can get out of a log but will also largely increase the percentage of No. 1 and No. 2 lumber.
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> Two or three of our mill plants, at the request of the writer, have made some experiments in cutting up 12-inch box, edge box and mill culls, in order to

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[a] See "Looking back on lumber waste," in American Lumberman, August 1, 1908, p. 45.

determine what percentage of No. 1 and No. 2 lumber especially could be secured in shorter lengths, if this lumber was remanufactured with this end in view. From these experiments we have found that in cutting up 12-inch box we obtained over 450 feet of No. 1 and No. 2 lumber, and out of about a thousand feet of 12-inch box there were only, approximately, 175 feet of lumber which should have remained in 12-inch box, or, in other words, only 175 feet out of the thousand did not justify remanufacture. The value of the No. 1, 2, and 3, etc., obtained from a thousand feet of 12-inch box, assuming that we had sale for it, in lengths of 4 feet and up, was very close to $22. The value of 12-inch box is $18.50. This lumber can be remanufactured at a cost certainly not exceeding $1.50, which would leave a clear profit of $2 a thousand to the manufacturer, or 10 per cent, approximately, more than he gets for his lumber now.

In the case of edge box, in the experiments which I had made I found that saving, much to my surprise, even greater than in 12-inch box. Cutting up the edge box in a similar manner to that of the 12-inch there was obtained out of a thousand feet $19.40 worth of lumber, according to the list price. The value of that amount of edge box would have been $15. Adding $1.50 for the cost of manufacture would still leave the manufacturer a profit of $2.90 a thousand on his edge box thus remanufactured, or a clear profit of approximately 20 per cent.

Cutting up a thousand feet of mill culls in a similar manner yielded lumber to the value of $19. Mill culls, I believe, are worth $13 a thousand feet. Adding to this the cost of remanufacture and subtracting from the above would leave a profit of about $4.50 to the manufacturer due to remanufacturing his cull lumber, or a saving of over 30 per cent. The question arises right here, How far can the present North Carolina rough-pine manufacturer enter into the details of cutting up his lumber, and will it pay him? Is it better for him to manufacture a trifle less lumber and get much better returns per thousand feet? Are we not in many instances getting out in our sawmills quantity at the expense of quality, grade, and value of output? These are all serious questions for consideration and there are hundreds of others which I will not mention. If we continue to put our No. 1 lumber into slabs in order to feed it to a hog, that it may furnish steam for our plants, or cut off 2 feet from the end of a 16-foot No. 1 stock because of slight blemish at the end or on account of the log having been cut an inch too short in the woods, there is no law that I know of to prevent this crime! In my judgment the average of us are wasting 5 per cent of the output of our logs, according to present methods. Is this worth anything to us? Are we so prosperous that it does not make any difference?

Practical forestry is beginning to be recognized in our section of the country, and all eyes at this time seem to be turned to the trees which are being fast cut down—the timber resources of the country are being exhausted rapidly. Measures are being taken to replenish in part at least this vast quantity of lumber cut. This is a very commendable movement and one which should receive the encouragement of our association. At the same time would it not be wise for us to undertake to get from the trees which we do cut down in the course of our business all of the lumber that we possibly can, and utilize every portion of them that we reasonably can? As timber grows scarcer such portion of the log as heretofore was waste will be more and more utilized. This condition will necessarily cause many of us to remodel our ancient plants in order that we may not be required to use merchantable lumber in the furnaces to make steam. In olden times the waste was at a maximum. Our forefathers did not begin to use any portion of the wood until they reached the heart. We have increased that portion of the log which is salable until we have almost reached the bark. In many classes of goods which are manufactured now the bark itself is being utilized, and in many places the sawdust as well.

[NOTE.—The figures with reference to the value of lumber used in this article are based on the price list of December 12, 1905. Since that time an increase in the price of lumber simply magnifies the results obtained, as shown.]

WASTE DUE TO CARELESS MANUFACTURE.

The loss in kerf, slabs, and trimmings constitutes by far the heaviest waste in converting logs to merchantable form. At least a portion of this waste is absolutely necessary and should not therefore be considered a waste at all. But there is another source of loss which is unnecessary and which can be easily avoided. This is the loss due to carelessness in manufacture. Hardly any process in the mill is free from it, and when taken for the entire country the waste which occurs is extremely heavy. No definite figures can be given on this subject, but an effort will be made to show how the waste occurs.

In most sawmills when the log reaches the log deck it is put onto the saw carriage by means of "kickers" and "loaders." These are usually iron or steel bars of various shapes, often terminating in sharp points or edges. It frequently happens that logs are broken outright by a careless manipulation of these tools. More often holes are gouged in the sides of the logs, which, although not serious when the bark is still on the log, may entail a considerable waste when the logs come into the mill peeled.

The "nigger" is another frequent cause of waste. The "nigger" is used to put and to turn the log on the carriage. It is a long steel bar or rod fitted with sharp hooks. Unless carefully manipulated the hooks tear the lumber in the log, especially after the log is squared. It often happens when the "nigger" does not work smoothly that the sawyer impatiently pushes it up and down an unnecessary number of times, and violently and repeatedly slaps the log with it. In such cases there is a considerable loss of lumber, for the torn surface of the plank or log must be cut off and thrown on the slab pile, unfit even for lath.

A very heavy loss is caused by setting the log carelessly on the carriage. Most set works are manipulated by means of ratchets. A pin quadrant or scale is attached to a circular slide close to a set lever, graduated in sixteenths of an inch, and having a hole opposite each graduation. A pin inserted in the one indicating the thickness to be sawn limits the travel of the lever, and correspondingly the movement of the set beam of the carriage and the log. After the set works have been used for some time and the machinery becomes more or less worn, one or both of the following things may happen: The hole becomes worn, so that the pin does not fit snugly but gives with the manipulation of the lever; or the pin becomes worn, with the same result. The effect is to move the setting beam too far and to cut the boards thicker than intended. This extra thickness is a total waste, since it is dressed off at the planing mill. The waste is cumulative and may amount to from 3 to 5 per cent of the output. This loss can be obviated by a frequent inspection of the machinery.

The effect of careless sawing, edging, and trimming is admirably stated by E. A. Braniff.[a]

> The profits of milling depend to a considerable extent upon the sawyer, the edgerman, and the trimmer. Many mill owners make the mistake of gauging their sawyer's ability entirely by his speed. It is he who sets the pace for the mill crew and they must keep up with him; therefore every extra thousand feet cut reduces the average milling cost. Broadly speaking, however, what the average sawyer gains in speed above the normal cut he loses in the quality of his product, especially if he is sawing valuable timber, such as yellow poplar. In order to get the best results the sawyer must take time to look at his log and turn it on the carriage as often as necessary. The sawyer whose sole

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[a] "Grades and amount of lumber sawed from yellow poplar, yellow birch, sugar maple, and beech," Bulletin 73, Forest Service, pp. 21–22.

aim is to make a big cut is the most expensive man the mill owner can employ for the work.

Rapid sawing necessitates rapid work at the edger and trimmer. Much may be lost by inefficient men at these machines. They handle several thousand boards every day, each of them a separate problem which must be solved instantly. The loss of 1, 2, or 3 cents on a piece of lumber by improper edging or trimming is not much in itself, but when these mistakes accumulate, the aggregate per day is often enough to pay the workman's wages several times. The edgerman has no time to stop and make calculations for each separate board. He stands in front of a stream of boards which he must feed into the machine as fast as the live rollers bring them to him. He can, however, be made so thoroughly familiar with the principles of his work that a glance at a board as it comes to him will usually be enough to tell him what to do with it.

The loss entailed in working night shifts and the waste incurred in unduly large mills are closely allied to the waste due to carelessness.

It sometimes happens that owing to a special rush order, or because the logging operation is far ahead of the milling operation, a night shift will be put in the mill for the emergency. In such cases, since it is almost impossible to obtain a complete crew of mill hands for a short time, the regular crew is split up, with the result that the night shift consists mostly of second-class men, while both shifts run short handed. The regular setter then becomes the sawyer, the dogger takes the place of the setter, the slab cutter may be advanced to the position of trimmer, and so with the rest of the men. The waste which occurs through such an arrangement is very great, for not only are the hands not expert enough to do the work, but the fact that the crew is smaller than normal adds to the waste and the confusion. In one mill observed it was estimated that the waste caused by putting on a double shift for two weeks amounted to about 15 per cent of the total output for the two weeks' night work.

Some mills work a double shift regularly, and the loss is not so great. Still even here the listlessness of the night workers will cause greater waste than would be the case with an all-day crew, besides an output of more poorly manufactured lumber.

It is generally assumed by mill men that lumber can be manufactured $2 per thousand cheaper by working double shifts, because with a given fixed capital there is a double output. This assumption does not take into consideration the additional waste and the additional wear and tear on the machinery which, in the long run, may nearly offset the gain.

It is now conceded by most mill men that very large sawmills are not economical, i. e., it pays better to operate two medium-sized mills than a single large mill, since it is difficult to take care of the output of the large mill. The waste of lumber at a large mill is proportionately greater than in a medium-sized one.

The waste caused by carelessness in manufacture, by working night shifts, and by the operation of unduly large mills, when taken for the entire country may be very conservatively placed at 4 per cent of the total output, though, from its very nature, no definite data can be collected on this subject. As already said, this waste is unnecessary; it is mainly an absolute waste, although a small portion of it may be utilized for lath and shingles.

WASTE IN GRADING.

The bulk of all the lumber manufactured is graded by standard rules, adopted by the various lumber manufacturers' associations.

The difference in value between two consecutive grades varies from $3 to $10 or more per thousand feet. According to present grading rules the class of a board may be increased one or two grades by a judicious trimming or edging. In other words, the actual money value of a board is increased if part of the board is cut off and thrown away. To take a specific example: A yellow poplar board 16 feet long and 21 inches wide, containing 28 board feet, has, besides a few small scattered knots equivalent to two standard defects, one large knot about 8 inches from one end. According to the grading rules of the National Hardwood Lumber Association the board will be classed as No. 1 common, and be worth, at $23 per thousand board feet, a little over 64 cents. By trimming off the large knot and (according to the standard length rule) reducing the board to 14 feet in length, containing 25 board feet, the board is raised to the firsts and seconds grade, which commands a price of $44 a thousand for boards more than 18 inches in width. The value of the board is now $1.10. By sacrificing 3 board feet the value of the board was almost doubled. Yet the board was not really changed in character, and nothing was added to it which it did not already have. On the contrary, part of a board having in itself some value was thrown away. This is perhaps an extreme case, but illustrates admirably the heavy premium put on waste by the present grading rules. The waste due to this source was included in the loss through edging and trimming. It is emphasized here merely to indicate a possible saving. There is no doubt that the loss amounts to from 3 to 5 per cent and can be entirely saved. Pressure should be brought to bear on the grading bureaus of the various associations to revise their rules so that no premium will be put on waste of lumber.

THE LOSS OF THE WASTE.

So far, the question of waste has been considered chiefly from the point of view of lumber production. That is, if a portion of log fit for lumber were converted into sawdust or slabs, it is classed as waste. Such may be entirely necessary, as in the case of a certain minimum percentage of kerf without which no lumber can be manufactured, but in so far as it is converted into sawdust when it might have made boards and plank. All kerf is waste of lumber (it is an actual, though necessary waste). It is now in order to consider the loss of this waste material.

Sawdust is almost a total waste. Most of that which is used is as fuel under the boilers; part of it goes into the slab burner; a very small fraction of it is sold for stable bedding, ice packing, etc. Of the cut of 7,121,000,000 board feet of lumber reported in answer to the circular letters already mentioned, only about 2½ per cent of the sawdust produced was used for other purposes than fuel. A large percentage of the sawdust is left in heaps in the woods because there is absolutely no demand for it. The question of utilizing the sawdust and waste slabs is discussed by Doctor Bristol in his report to the Commission.

As has already been shown, slabs and edgings are partly used in making lath. Most of them, however, as well as most of the trimmings, are used as fuel or are entirely wasted. This waste is not necessary. Part of the slabs should be sold as boards, while of the material unfit for lumber the greater portion should be utilized for purposes requiring small dimension stock. A long list could be given of articles which might be made from this waste, most of which are now being made from lumber better fit for other purposes; the more common articles are matches, toothpicks, excelsior, spools and bobbins, dowels, pail handles, clothespins, wooden dishes, toys, and novelties, the smaller sized packing boxes, shoe pegs, and skewers. The Forest Service is about to undertake a study of these industries with a view to suggesting a closer utilization of the present mill waste. It is not at all impracticable to use the slabs and edgings of certain species of wood, such as hemlock, spruce, etc., for pulpwood. The sawdust and slabs of other species, such as chestnut, chestnut oak, etc., may be used for the extraction of tannin. A small percentage of waste is already utilized in this manner, but much more can be used if only the mill men could get into touch with the tannin and pulp men.

WASTE OF BARK.

In the above calculations the waste is expressed in percentage of the volume of peeled logs. But the bark itself constitutes a large percentage of the log, and, since very little use has been discovered for bark, the loss of it may also be considered a waste. Table 3 shows the volume of the bark expressed in percentage of the total volume of the log.

TABLE 3.—*Percentage of bark in total volume of logs.*

Species.	Per cent.	Species.	Per cent.
Lodgepole pine	6	Chestnut [a]	13
Western hemlock	10	Red oak [a]	13
Eastern balsam	10.5	Yellow poplar [a]	13
White pine	11	Western yellow pine	15
Eastern (red) spruce	11	Douglas fir (second growth)	16
White oak [a]	12	Douglas fir (first growth)	20
Loblolly pine	13	Sugar pine	20

[a] Mostly estimated.

Hemlock bark has long been a valuable article of commerce, since it is extensively used in leather tanning. In fact, up to five or ten years ago in certain parts of the United States, the bark was the only portion of the hemlock used, for the lumber was not considered merchantable. Chestnut bark and the bark of certain oaks is also valuable for tannin. The bark of the other species of trees is, however, considered valueless and is left in the woods or sent to the slab burner.

WASTE IN MANUFACTURE OF VENEERS.

Statistics show that 348,000,000 board feet, log scale, were manufactured into veneering in 1907. Although very small when compared with the amount of wood manufactured into lumber, and only about one-fourth of the amount converted into cooperage stock, yet it represents the annual growth of a well-stocked forest of 1,160,000 acres, growing at the rate of 300 board feet per acre per year. The waste entailed in the manufacture of veneer is also very large, and a saving of this waste is greatly to be desired.

Veneers are cut either with a saw or with a knife. If a knife is used, the veneer is either sliced or rotary cut. In the first case the log is usually stationary and the knife slices off thin layers of wood. If rotary cut the log is revolved slowly against a stationary knife. Answers received to a schedule of questions sent to the leading veneer men show that 88 per cent of all the veneer made in 1907 was rotary cut, 6 per cent was sliced, and 6 per cent sawed.

The chief sources of waste are as follows:

1. Defective ends on the logs cause ragged edges on the veneer, which must be cut off. This waste, as reported by the veneer men, amounted to 3.5 per cent of the lumber used.

2. Checks and cracks are serious defects, since it is almost impossible to use such logs for veneering. The waste from this source is 6 per cent of the lumber used.

3. Damaged sap that must be trimmed off constitutes a waste of 3.2 per cent.

4. In rotary cut veneer the core of the log, usually over 6 inches in diameter, can not be cut into veneer. As reported by the veneer manufacturers, the cores represented 16.5 per cent of the lumber used. Most of the lumber represented by the cores was utilized in one way or another, usually for some cheap product for which an inferior grade of lumber could have been used. In some mills, however, the core is used only as fuel for the furnace or is not utilized at all. Reports show a total waste from this source of 3.1 per cent of the lumber used for veneer.

5. Veneer from its very nature is very fragile, and unless it is carefully handled there is a heavy loss due to breakage. The output of 5 per cent of the lumber used, as reported, was broken in handling.

6. A further loss of from 4 to 5 per cent of veneer is caused by checking, warping, and staining in the process of seasoning.

Thus, from the sources enumerated above, there is a waste of about 25 per cent of the total lumber used in this industry. An additional loss of 5 per cent may be safely allowed for other wastes, such as carelessness, etc., bringing the total loss up to 30 per cent.

There is no doubt that part of this waste can be saved by more careful manufacture, while a part of the necessary waste may be utilized in various ways.

WASTE IN MANUFACTURE OF COOPERAGE.

About 1,250,000,000 board feet of lumber were used in the cooperage industry in 1907. Of this amount about 500,000,000 feet were used for tight and the rest for slack cooperage.

The following extract, taken from a Forest Service report prepared by a man who has made a special study of this industry, discusses the loss incurred in the manufacture of slack cooperage and suggests methods of saving the waste:[a]

> Waste in the manufacture of any highly specialized wood product seems to be a necessary and unavoidable evil, and the manufacturer of slack cooperage is perhaps not more wasteful than his fellow wood users. Though probably as much as 40 to 50 per cent of the round timber is unused in the manufacture of staves and hoops and about 75 per cent in the manufacture of

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[a] Unpublished report on "Woods for Slack Cooperage and their Economic Utilization," by J. J. Levison, pages 14–19.

heading, only part of this loss can be prevented. The waste is not due to one particular cause but rather to a large number of small causes, which in the aggregate amount to considerable.

The cooperage man must have green timber, and yet hundreds of logs or blocks will often be allowed to lie on the yard or in the woods until they become too dry or too checked for cooperage purposes. In Ohio a log is considered green which has been cut five months or less, or until it begins to shed its bark.

At the mill there is often great waste in cutting logs into heading lengths when they are intended to be cut into stave lengths. Heading blocks will often be cut 21 inches long when only 17½ or even 15 inch heading will be circled out of them, and the matcher, in his haste or carelessness, will also frequently cause another waste of 2 inches by the wrong choice of boards. When logs intended to be used for staves are cut in the woods into lengths in multiples of 32 inches and then found when they reach the mill to be unsuitable for staves they are divided into 21-inch lengths and used for heading. This will cause a waste of 3 inches in a log that was cut for six stave lengths, and a waste of 13 inches in a log that was cut for five stave lengths. In the latter case there will be a wasted piece which is too short for a heading block and which will go into the waste pile. To prevent this waste, there is need of intelligent supervision and knowledge on the part of the woods foreman as to the purpose for which each log is best suited. Many logs are also cut a few inches too short in the woods, and the last block must be thrown out at the mill. The logs can often be cut longer, either by going a little higher into the top or by cutting a lower stump.

Improper bolting for staves is another cause of considerable waste. In many mills, instead of being first cut into short blocks and then into bolts, the whole log is first sawed lengthwise into "cants" (sections) and then divided into the requisite short bolts. As generally practiced, this method does not give bolts of the proper slanting form. Moreover, the grain of the log does not generally run parallel to its axis for the entire length, so the bolts cut by the canting method will be more or less cross-grained and hence produce an inferior grade of staves and cause a greater waste.

The preparation of bolts by splitting instead of sawing, still practiced at a few southern mills, is also wasteful one. The fibers of a split bolt generally run parallel to its axis, while the straightness of the grain of a sawed bolt depends upon the skill of the man at the bolting saw. The bolter is apt to produce a cross-grained bolt which will give rough staves, but the waste thus caused is small compared with that which always results from the split bolt. At least the first two and the last two staves in every split bolt have to be discarded because the sides of the bolt are uneven, so that for a given volume of timber sawed bolts will produce more staves of good quality than can be obtained from split bolts.

Carelessness in stave jointing is a very common occurrence and produces much waste. A hard wood with many knots will often cause the jointer to cull hundreds of staves, the defects of which could have been cut around and the staves saved.

After the staves have been manufactured there is a very considerable amount of waste in seasoning. Correct piling is an important factor in both air and kiln drying, and close attention to it would save much stock.

The utilization of the unavoidable waste is a problem which sooner or later will confront every manufacturer of wood, and an early consideration of the subject is most advisable. Whether the loss be due to the oversight of the manufacturer or to the nature of the process, the quantity of discarded wood in slack cooperage manufacture is great, and a considerable proportion of it, such as slabs, culled blocks, and hoop planks, could be rescued from the waste pile at a profit. In many cases the slabs could be used for sawed hoops at a reasonable gain and the culled and broken hoops could be turned into head liners. There is also a possibility that the culled blocks and hoop planks could be made into dimension stock or some other salable product.

The first concern of the cooperage manufacturer should be to prevent the waste as far as possible, and this should start with the cutting of the tree in the woods where a determination as to the purpose which the log will best serve is fully as necessary as a careful working up later.

A great saving of waste can be made in many cases by bettering the methods of manufacturing and handling the stock. The lack of a combined stave, heading, and hoop mill causes much waste. In order to utilize every log and give each one its most economic place, there must be a combination of at least stave and heading manufacture. A log that will not make a good hoop will often make good staves, and one too poor or too small for staves will often turn out excellent heading. But the numerous mills that make only one kind of stock are compelled to throw out unsuitable logs, blocks, and planks that could have served a useful purpose in some other branch of the slack-cooperage industry. Not only should there be, as far as possible, a combination of the various branches of the industry, but as well a careful selection of the machines in the mill and careful attention to their operation and maintenance.

The utilization of the waste pile is a possibility that the local markets and the labor question must, in a large measure, determine. In some localities the waste is selected and sold to factories for the manufacture of wooden novelties, such as shoes, toys, spools, toothpicks, clothespins, and the like. Further investigation may develop the economic possibility of using other parts of the waste for distillation or for pulp. The use of spoiled finished staves as substitutes for shingles on cheap buildings is suggested. Such of the waste as can not be put to any of these uses will supply fuel, and is so used in several mills, the ashes being sold locally for fertilizer, or shipped to be mixed with southern phosphates.

From the above extract it may be seen that Mr. Levison's conclusion that from 40 to 50 per cent of the round timber is wasted in the manufacture of staves and hoops, and as high as 75 per cent in the manufacture of heading, is not exaggerated.

Although the cooperage manufacturers realize that there is a certain loss of lumber incurred in their industry, yet few realize how large this loss is. In a schedule of questions sent out to the leading cooperage men the following was included: "Comparing the volume of the logs or bolts used with the volume of the product, what per cent of material is wasted in the manufacture of staves?" The answer to this question varied from 2 per cent to 66 per cent. The next question on the schedule, "In what way, if any, is this waste utilized?" brought an almost unanimous answer, "For fuel."

Answers to another question on the schedule bring out the fact that, on an average, slack stave bolts are cut 2 inches longer than the staves are to be. Assuming an average length of stave of 24 inches, there is a loss of one-thirteenth of the bolt length, or 7.7 per cent of the total lumber cut for staves.

A heavy loss is also entailed in seasoning cooperage stock. Eighty-five per cent of the output of slack staves is air-dried and 15 per cent is kiln-dried. The loss in air-drying comes from warping, checking, and staining, and amounts to about 4 per cent, on an average. Almost all the loss in kiln-drying occurs from warping, and amounts to but 1 or 2 per cent.

Forty per cent of the slack heading produced is air-seasoned, 60 per cent is kiln-dried. The loss through warping, checking, and staining in the first case averages 5 per cent. If kiln-dried, it amounts to only about 3 per cent. This indicates a loss of from 3 to 4 per cent in seasoning slack cooperage stock.

Of tight staves 40 per cent are kiln-dried, with an average loss through checking, warping, etc., of 2 per cent, and 60 per cent are air-dried, with an average loss of 6 per cent.

Tight heading is half air-dried, half kiln-dried. The loss in the first case is 5 per cent, in the latter case it is only about 2 per cent. The average loss incurred in drying tight cooperage is therefore about 4 per cent.

The methods of reducing loss in cooperage are (1) through greater care in the various processes of manufacture; (2) better and more highly specialized machinery; and (3) a more thorough utilization of the waste.

WASTE IN USE OF TIMBER.

By McGarvey Cline,
United States Forest Service.

INTRODUCTION.

The following discussion is based upon data compiled by the Bureau of the Census and upon reports furnished to the Forest Service by lumber dealers and manufacturers representing the larger lumber-consuming industries. A rather careful search through the lumber trade journals and library references disclosed very little information on the subject of this report. In many cases the data secured were not complete enough to be more than indicative; the discussion, therefore, is only to be regarded as an effort to present the best material available.

CONSUMPTION OF LUMBER BY DIFFERENT INDUSTRIES.

Reports received from 36 railroads, representing 37 per cent of the total railroad mileage of the United States, show that the various lines reporting used, in 1907, 417,800,000 board feet of lumber for car building and 183,600,000 board feet for bridge timbers. Assuming that this same rate of consumption applies to the total mileage (210,000 miles) the railroads of the United States in 1907 consumed 1,128,000,000 board feet for car building and 496,000,000 board feet for bridge construction. In addition to this, 1,155,000,000 board feet of sawed cross-ties were used; these various items making a total consumption, during 1907, of 2,797,000,000 board feet, 7 per cent of the total lumber cut for that year. It must be remembered that this discussion of lumber consumed by the railroads applies only to sawed lumber and does not include the enormous quantity of forest products used in the form of hewed ties, piling, and poles.

Table I contains data taken from Part I of the Census of Manufactures of 1905. At the bottom of the table the matter contained in the various columns is described. The classification of industries, shown in column A, is that given by the Bureau of the Census. The figures in column B show the cost of the raw material consumed by the different industries. Column C gives the average value of the lumber consumed in dollars per thousand feet board measure. These values are based upon the prices of lumber prevailing in 1904. Column D is secured by dividing the figures in column B by those in column C.

Table I.—*Consumption of lumber by wood-using industries in 1904.*

Lumber-using industries.	Cost of material used.	Average price per 1,000 feet B. M.	Lumber consumed, millions of board feet.	Lumber consumption in per cent total lumber cut.
Furniture and cabinet work:				
Furniture	$60,861,123	$16	4,300	12.60
Coffins	9,156,299	14	655	1.92
Billiard tables	885,676	17	52	.15
Picture frames	4,825,702	16	300	.88
Refrigerators	3,086,886	14	220	.64
Sewing machines	2,266,628	16	141	.41
Show cases	2,254,787	16	141	.41
				17.01
Boxes:				
Cigar	3,366,823	18	187	.55
Packing	31,397 410	12	2,610	8.00
				8.55
Agricultural implements	18,200,000	16	1,140	3.30
Carriage and wagon manufacturing	10,338,000	20	516	1.50
				4.80
Ship building	6,700,000	12	558	1.64
Miscellaneous:				
Artificial limbs	122,942	18	68	.02
Lasts	689,103	16	43	.13
Matches	3,142,750	12	220	.76
				.91

Assuming that the building trades consume all the lumber not included in the above estimates, Table II gives the distribution of the lumber cut of 1907 among the principal wood-using industries both in board feet and in percentages of the total cut. This table also assumes that the percentage of the total lumber cut consumed by the different industries, listed in Table I, was the same in 1907 as in 1904. Undoubtedly this assumption is not entirely correct, but it is thought that the relative quantity of material used by the different industries would change only slightly during a period as short as three years.

Table II.—*Showing division by industries of total lumber cut, 1907.*

	Per cent of total cut.	Million board feet.
Building trades	60.0	24,150
Furniture	17.0	6,840
Boxes	8.6	3,460
Railway and transportation	7.0	2,820
Implement and vehicle	4.8	1,930
Shipbuilding	1.6	644
Miscellaneous	1.0	402

KINDS OF WASTE.

A study of the wastes associated with the industrial use of lumber may be divided into three classes:

1. Wastes in seasoning.

2. Wastes in manufacturing, or factory wastes.
3. Wastes due to improper use.

The third class of wastes is so interwoven with general economic conditions that it is almost impossible to deduce any definite conclusions regarding them. They will, therefore, not be considered in this discussion.

BUILDING TRADES.

The building trades, especially in the great lumber-consuming regions, secure practically all their lumber through wholesalers. Table III is based upon reports received from 340 architects. Columns 1, 2, and 3, respectively, under the sections of States, represent materials specified for high-priced, medium-priced, and cheap buildings. At the bottom of each column the number of architects reporting is given. The other figures represent the number of times the different woods were reported, expressed in percentage of the total number of reports. For example, it will be seen in Table III-A that out of 425 reports on woods specified for flooring in high-grade buildings in the New England States 41.4 per cent specified oak, 24 per cent maple, and 21.9 per cent yellow pine.

In the Pacific Coast States, out of 61 reports on the same item, 40.9 per cent specified oak, 36 per cent maple, and none specified yellow pine; 17 per cent, however, specified Douglas fir. This table is interesting in that it shows which woods are most used in the various parts of the country for flooring, siding, sheathing, joists, and shingles.

TABLE III.—*Woods specified by architects.*

A. FLOORING.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
Oak	41.3	14.0	2.3	48.20	23.40	5.0	43.3	26.7		40.0	25.0		40.3	16.2	3.7
Maple	24.0	19.5	8.0	29.20	29.00	16.6	13.5			26.7	8.3		36.1	19.5	3.7
Yellow pine	23.9	55.2	62.6	9.70	36.20	57.3	34.9	73.3	89.0	22.2	56.3	75.0		2.4	
Birch	5.2	5.2	2.6	8.80		2.6	4.3						6.6	7.2	
Spruce	2.8	3.9	17.7		4.30										
Cherry	2.4			(a)											
Mahogany	.9	2.2	5.9	1.40	1.40	14.0									
White pine	(a)	(a)	(a)												
Ash	(b)				(b)		4.3								
Teak	(b)			(a)											
Walnut	(b)														
Chestnut	(a)														
Cypress	(a)	(a)	(a)	(a)	(a)	(a)									
Douglas fir	(a)	(a)	(a)	1.35	1.40	4.0					8.4	25.0	17.0	54.7	92.6
Hazel	(a)														
Sycamore	(a)			(a)											
Beech		(a)		1.35	5.28	(a)									
Basswood			(a)												
Gum					(a)	(a)				11.1					
Hemlock			1.9	(a)	(b)	(b)									
Norway pine			(a)			3.0									
Red cedar		(a)													
Total reports	425	426	310	222	210	150	23	15	9	18	12	8	61	42	28

a Reported only once.

b Reported only twice.

Column 1=High-priced buildings.
Column 2=Medium-priced buildings.
Column 3=Low-priced buildings.

TABLE III.—*Woods specified by architects*—Continued.

B. SIDING.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
White pine	49.8	31.4	27.7	35.8	28.3	22.6				40.0	11.2				
Cypress	14.4	21.6	22.6	20.2	17.2	15.7					22.2	9.2			
Spruce	13.4	19.7	20.6	4.2	5.5	6.0									
Yellow pine	4.5	9.0	13.7	3.4	6.9	13.2	66.7	66.7	70.0	40.0	22.2	53.7			5.7
Poplar	5.0	4.7	4.4	14.4	16.6	15.1	34.0	33.3	20.0						
Oak	4.0	(*b*)													
Cedar	4.0	3.1	2.2	2.5	3.4	(*a*)						9.2			
Douglas fir	1.6	2.7	2.2	8.5	7.6	5.0					11.1	9.1	11.5	20.6	31.7
Hemlock	1.7	3.5				1.9									
Red cedar	1.6	2.3	1.3	5.1	3.4	1.9							46.3	6.9	5.7
Redwood	(*b*)	2.0	2.2	5.9	6.9	3.2				20.0	33.3	18.8	38.4	69.0	54.3
Basswood	(*a*)	(*b*)	3.1	(*a*)	2.8	12.0									
Sugar pine													3.8	3.5	2.6
Beech						(*a*)									
Birch		(*a*)													
Cottonwood					1.4	1.5									
Gum									10.0						
Hazel			(*a*)												
Maple		(*a*)													
Norway pine					(*a*)	1.9									
Total reports	201	257	226	118	145	150	9	12	10	5	9	11	26	29	35

a Reported only once. *b* Reported only twice.

Column 1=High-priced buildings.
Column 2=Medium-priced buildings.
Column 3=Low-priced buildings.

C. JOISTS.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
Yellow pine	51.2	34.8	26.4	61.2	48.3	38.7	100.0	91.6	87.5	40.0	50.0	77.7			
Spruce	29.7	39.6	27.2	3.1	1.32	1.48									
Hemlock	12.1	22.2	43.5	4.35	14.5	38.0									
White pine	2.2	1.02	.725	8.7	12.4	8.05						11.2			
Oak	1.92			1.86	.69			8.4							
Norway pine	.96	1.02	.51	13.7	16.6	10.2									
Chestnut	.96	.34	.725												
Maple	.64	.68													
Poplar	.32	.34		1.24	.69	1.46									
Douglas fir			.725	6.84	5.5	2.19				60.0	50.0	11.1	100.0	100.0	100.0
Cypress			.51												
Gum									12.5						
Total reports	313	295	276	161	145	137	10	12	8	10	8	9	25	20	27

Column 1=High-priced buildings.
Column 2=Medium-priced buildings.
Column 3=Low-priced buildings.

TABLE III.—*Woods specified by architects*—Continued.

D. SHEATHING.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
Yellow pine	35.7	32.9	33.8	45.0	45.0	37.4	80.0	68.7	70.0	71.4	80.0	80.0			
Spruce	20.7	19.8	17.5	2.8	2.3	1.6									
Hemlock	16.9	23.0	39.6	11.7	21.4	39.9									
White pine	13.6	5.7	3.6	22.5	16.0	11.7				14.3					
Cypress	5.2	8.9	3.3	3.6	3.6	3.1				14.3	10.0	20.0			
Ash	2.5	2.4													
Maple	2.7	2.1	(a)												
Oak	2.7	(a)	(a)				10.0	6.3	10.0						
Basswood	(b)	3.2	2.2					6.3							
Douglas fir	(b)	(b)	(a)	4.5	2.3	1.6					10.0		84.6	88.5	88.5
Mahogany	(b)														
Norway pine	(b)			8.1	8.4	4.7									
Poplar	(b)	(a)		1.8	(a)		10.0	12.5	10.0						
Cedar	(a)														
Chestnut	(a)	(b)	(a)					6.2							
Gum									10.0						
Redwood													15.4	11.5	11.5
Total reports	233	277	275	1:1	131	128	10	16	10	7	10	10	26	26	26

[a] Reported only once.

[b] Reported only twice.

Column 1—High-priced buildings.
Column 2—Medium-priced buildings.
Column 3—Low-priced buildings.

E. SHINGLES.

Species.	New England and Middle States.			Northern and Central States.			Southern States.			Western States.			Pacific Coast States.		
	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.	1.	2.	3.
White cedar	48.7	52.0	43.6	31.0	32.6	28.9				12.5					
Cypress	24.7	27.0	25.7	15.6	20.3	21.6	55.5	42.8	33.3	12.5	25.0	37.5			
White pine	8.9	7.8	9.6	22.4	9.4	13.4	22.2	7.1	11.2	12.5					
Red cedar	7.7	7.8	7.5	.9.1	28.2	20.4		7.1		50.0	62.5	50.0	61.5	56.5	50.0
Redwood	7.3	4.3	2.1	9.9	5.1	5.2	11.1	14.3	11.1				38.5	43.5	50.0
Douglas fir	2.7	(a)	1.2	2.0	4.4	1.5				12.5	12.5	12.5			
Spruce	(a)	1.1	5.4												
Yellow pine	(a)		1.2			2.2	11.2	28.7	33.3						
Hemlock			3.7			3.0									
Oak	(a)														
Poplar						.8			11.1						
Norway pine						3.0									
Total reports	247	282	241	152	138	134	9	14	9	8	8	8	39	39	42

Column 1—High-priced buildings.
Column 2—Medium-priced buildings.
Column 3—Low-priced buildings.

[a] Reported only once.

To ascertain the relative amount of different forms of materials consumed by the building trades, schedules were sent to wholesale lumber dealers in different sections of the country. Replies were received from most of the important markets of the country, but they were not uniformly filled out, and in many cases were incompletely answered. The replies which were sufficiently complete to be used in this report cover 780,400,000 board feet of soft woods and 34,600,000 board feet of hard woods. Table IV is based upon these schedules and shows the aggregate quantity of each species reported and what percentage of this quantity consisted of the various forms indicated by the column headings.

TABLE IV.—*Stock handled by wholesale lumber dealers.*

Species.	Total quantity reported.	Common boards.	Inside finish.	Siding.	Ceiling.	Flooring.	Plank and dimension.
Soft woods:	*Board feet.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Yellow pine	348,321,000	21.4	10.5	4.3	3.3	5.2	55.3
Douglas fir	138,434,000	10.6	4.8	4.1	4.1	6.4	70.0
Redwood	107,458,000	6.3	22.6	20.1	4.8	.9	45.3
Northern pine	47,922,000	81.0	10.5	.5			8.0
Spruce	12,000,000	100.0					
Western pine	6,277,000	40.5	18.8	4.6	.5	1.5	34.1
Hemlock	785,000	42.0					58.0
Cedar	337,000			100.0			
Cypress	270,000	92.6	6.3				1.1
Unclassified	117,650,000	18.9	57.0	1.3	.4	1.5	20.9
Hard woods:							
Oak	5,955,000	24.2	.3			.3	75.2
Poplar	3,655,000	45.7	.4	28.1	.8		25.0
Birch	2,589,000	96.6	.4			3.0	
Maple	243,000	28.8				71.2	
Other hard woods	3,565,000	100.0					

Table V is compiled from the same set of schedules. The column headed "Distribution by form" shows that of the soft woods handled 44.7 per cent was finish and siding; 12.6 per cent common boards; 28.6 per cent plank; 14.1 per cent rough dimension. The horizontal column marked "Distribution by industry" shows that 82 per cent of the total soft woods was consumed by the building trades; 2.5 per cent by the furniture factories; 15.2 per cent by the box factories; and 0.3 per cent by the vehicle and implement industry. This table also shows what percentage of the total quantity of each form considered is consumed by the building trades, furniture, box, and vehicle and implement factories. For example, all of the finish and siding reported was consumed by the building trades, while of the soft-wood boards reported 39 per cent was used for building, 5.2 per cent for furniture, 54.8 per cent for boxes, and 1 per cent for vehicles and implements. The lower part of the table indicates in a similar way the distribution of the hard woods handled. From these data on the quantity and form of the material consumed by the building trades, it seems that 50 per cent consists of finish, siding, and flooring; 5 per cent of sheathing and common boards; and 45 per cent of joists, scantling, and dimension.

TABLE V.—*Distribution of material handled by wholesale lumber dealers.*

Form of material.	Distributed by form.	Building trades.	Furniture.	Box.	Vehicle and implement.
Soft woods:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Finish and siding	44.7	100.0			
Boards	12.6	39.0	5.2	54.8	1.0
Plank	28.6	100.0			
Dimension	14.1	83.0	8.3	8.2	.5
Distributed by industry	100.0	82.0	2.5	15.2	.3
Hard woods:					
Finish and siding	12.0	100.0			
Boards	78.6	50.6	44.4	3.0	2.0
Plank	9.4	21.2	62.3		16.5
Distributed by industry	100.0	53.8	40.8	2.4	3.0
All woods		82.0	2.5	15.2	.3

WASTES.

In the building trades there is always a considerable percentage of waste lumber; therefore, after computing the exact quantities indicated in the plans for a building, contractors add the following percentages to the different items of lumber to cover waste. These figures were secured from various handbooks and from reports received from a few building contractors:

	Per cent.
Joists and scantling (very frequently no waste is allowed in these items)	2
Sheathing:	
Laid horizontally	17
Laid diagonally	20
Siding:	
Drop	20
Laid 4" to the weather	50
Flooring and ceiling, square edge:	
6-inch flooring	11
4-inch flooring	20
Flooring and ceiling, matched:	
6-inch flooring	17
4-inch flooring	20
2¼-inch flooring	33
1¾-inch flooring	40
Shingles:	
Plain roof	8
Gable roof	12

By further classifying the above figures it is found that in the use of finish, siding, and flooring the average waste is about 20 per cent; for sheathing it is 18 per cent, and for joists and dimension 2 per cent. These weighted according to the relative amounts of the various classes consumed give an average waste of 12 per cent in general building operations. It is estimated that from the mill to the consumer there is also 3 per cent waste in seasoning due to checks, stains, etc. The total waste, therefore, in building materials is approximately 15 per cent, which annually amounts to 3,600,000,000 board feet.

FURNITURE.

The lumber consumed by the furniture industry is with few exceptions in the form of board, plank, small dimension, and veneer. Table V indicates that 40.8 per cent of the hard woods handled by wholesale lumber dealers and 2.5 per cent of the soft woods are consumed by this industry, but the larger part of the material used is purchased direct from the mill operators or is manufactured at mills operated by large furniture concerns.

Practically all of the commercial hard woods, with the possible exception of hickory, furnish raw material for this industry. From card reports received from 2,482 furniture establishments in the United States it seems that the woods used, with respect to quantity, range themselves as follows:

	Per cent.		Per cent.
Oak	45	Elm	5
Maple	11	Gum	5
Birch	7	Chestnut	4
Yellow poplar	6	Basswood	4
Beech	5	Ash	3

All others, including walnut, mahogany, pine, hemlock, Douglas fir, etc., 5 per cent.

WASTES.

Reports from 61 manufacturers of different classes of furniture show an average loss of 5 per cent in seasoning furniture woods. Table VI is based on the same reports. It shows the average waste in manufacturing various classes from different grades of lumber. The estimates on waste associated with the use of different grades for any particular class of furniture varied considerably. The table, however, shows the range in the estimates furnished by giving the average of the highest one-tenth and the average of the lowest one-tenth of the total number of reports received on each item.

TABLE VI.—*Wastes in the furniture industry.*

[Based on reports received from 61 manufacturers of different classes of furniture.]

Classes.	Grades used.				
	Uppers, firsts and seconds.	No. 1 common.	No. 2 common.	Mill run.	General average.
Tables:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Average	22	34	39	32	32
Average high	29	46	47	36	
Average low	13	24	33	28	
Cabinets, desks, china closets, bookcases:					
Average	17	32	....	....	25
Average high	27	55	....	....	
Average low	10	15	....	....	
Chairs:					
Average	22	26	....	....	24
Average high	25	33	....	....	
Average low	15	20	....	....	
Bedroom sets:					
Average	25	31	36	....	30
Average high	25	34	43	....	
Average low	25	28	29	....	

In figuring the percentage of waste, most manufacturers measure up the amount of lumber required, according to the design of the piece of furniture under question, then add to this amount a certain percentage, which experience has shown necessary, depending upon the quality of the lumber to be used. In some cases the species is also considered, since some species contain more knots, checks, etc., than others. The table shows the range in wastes reported.

The grades most commonly used are firsts, seconds, No. 1 common, and No. 2 common.

The deduction from these figures is that 25 per cent is a conservative estimate for factory waste in this industry, or 20 per cent, expressed in terms of material purchased. Both factory and seasoning wastes combined amount approximately to 25 per cent, which represents an annual waste of 1,710 million board feet.

BOX FACTORIES.

Table V indicates that 15.2 per cent of the soft woods and 2.4 per cent of the hard woods handled by the wholesalers are consumed by the box factories. This industry, however, secures by far the largest part of its supply direct from the mill, very often the box factory being run in conjunction with the sawmill or a large planing mill.

Practically all low-priced woods are used. In the New England region white pine is the leading material, although spruce and hemlock, as well as poplar, basswood, chestnut, and other woods are also used. In the South Atlantic States, North Carolina pine is the prevailing material; in the Lake States white pine leads; in the Southern States a great variety of woods are used, cottonwood, gum, and yellow pine being the most important; in the Pacific coast States the western white pine, spruces, and firs predominate.

WASTES.

The loss due to seasoning box material is conservatively estimated at about 3 per cent, and the factory waste, which is generally expressed as a percentage of the actual volume of the material entering the finished box, varies from 10 to 20 per cent, 15 per cent being a conservative average. The combined factory and seasoning wastes would therefore amount to approximately 20 per cent, which represents an annual waste in board feet of 692,000,000.

RAILWAY AND TRANSPORTATION LINES.

The species furnishing the bulk of material used by the railroad and transportation lines are yellow pine, Douglas fir, and oak for car and bridge material; and for ties, in addition to the above, cedar, chestnut, western pine, tamarack, redwood, cypress, and several others in much smaller quantities.

WASTES.

Out of 35 railroads reporting on waste of material in car building, 4 report no waste, 6 report 5 per cent, 9 report 10 per cent, 12 report 15 per cent, and 4 report 20 per cent; this gives a general average of approximately 11 per cent. Out of 33 railroads reporting on waste in bridge building, 8 report no waste, 12 report 5 per cent, 8 report 10 per cent, and 4 between 10 and 15 per cent, with an average of approximately 6 per cent. Out of 30 roads reporting, 15 report no loss due to seasoning, 10 report between 1 and 5 per cent, 2 between 5 and 10 per cent, and 3 between 10 and 15 per cent, with an average of approximately 3 per cent. These averages weighted according to annual consumption give an average total waste of 10 per cent in bridge and car material, which represents an annual loss of 282,000,000 board feet.

VEHICLE AND AGRICULTURAL IMPLEMENTS.

These industries, as indicated in Table V, secure some material through wholesalers, but by far the larger quantity of lumber consumed is purchased in the form of plank, flitches, or small dimension, direct from the sawmills. The species most commonly used are as follows:

Box boards	Yellow poplar, cottonwood, red gum, tupelo.	Reaches	Oak.
Box cleats	Yellow poplar, cottonwood, rock elm.	Standards	Oak, rock elm, hickory.
Box beds	Longleaf pine, birch, oak.	Hounds	Oak, rock elm.
Bed cleats	Oak, rock elm.	Spokes	Oak.
Axles	Hickory, maple.	Rims and fellies	Oak, Osage orange (southern trade).
Bolsters	Oak, hickory.	Hubs	White, red, and willow oak, black and yellow birch.
Sand boards	Oak, hickory.	Doubletrees	Hickory, rock elm, oak.
Poles	Oak.	Singletrees	Hickory, rock elm.
Brake bars	Oak, rock elm.	Neck yokes	Hickory, rock elm.

SEASONING WASTES.

The hard woods used in vehicle manufacture are first air-dried from two to four years and then kiln-dried; accordingly, the loss due to seasoning such stock may be divided into losses due to air-drying and losses due to kiln-drying. The following table gives the total losses due to seasoning rough dimension, plank, and boards of the woods most generally used:

TABLE VII.—*Percentage lost in seasoning.*

Species.	Rough dimension.	Plank.	Boards.
Hickory	11	11	12
Oak	10	10	12
Poplar	12	11	11
Ash	9	11	12
Maple	6	9	6
Pine	10	7	6
Elm	7	8	3

These figures indicate an average waste of 10 per cent in seasoning vehicle and implement woods.

Table VIII is based on 159 reports received from manufacturers of carriages, wagons, wheels, rims, poles, shafts, and gears. The table shows the relative amount of waste in manufacturing the finished articles from different forms of material. For example, the waste in the manufacture of axles from dimension based upon 10 reports averages 16 per cent and the estimates furnished range from a minimum of 6 per cent to a maximum of 26 per cent. It is, therefore, evident that not much significance can be attached to the figures showing average waste. From the data it contains it is estimated that there is an average factory waste of 15 per cent in manufacturing the various parts of vehicles from raw material in the form of dimension, billets, plank, or boards. The total waste, therefore, in the vehicle and implement industries amounts to approximately 25 per cent, representing an annual loss of 482,000,000 board feet.

Table VIII.—*Wastes, vehicles and implements.*

[Based on reports received from 159 manufacturers.]

Article.	Form of material.															
	Dimension.				Billets and blocks.				Plank and flitches.				Boards.			
	Number of reports.	Average percentage of waste in manufacturing from rough stock.	Average high percentages.	Average low percentages.	Number of reports.	Average percentage of waste in manufacturing from rough stock.	Average high percentages.	Average low percentages.	Number of reports.	Average percentage of waste in manufacturing from rough stock.	Average high percentages.	Average low percentages.	Number of reports.	Average percentage of waste in manufacturing from rough stock	Average high percentages.	Average low percentages.
Axles	10	16	26	6												
Bent work	2	10	10	10					11	20	28	12				
Bolsters	8	12	22	4												
Carriage bodies													40	17	35	6
Gears	20	13	22	8					38	19	44	6				
Hubs					26	18	38	5								
Poles	14	11	18	4					9	29	45	13				
Rims									39	23	48	10				
Seats													9	20	25	13
Shafts	5	12	18	8					9	25	37	13				
Shaft crossbars									3	28	35	25				
Spokes					23	27	54	8								
Single and double trees	1	8	8	8					8	27	35	19				
Wagon bodies									66	17	42	6	26	18	31	9
General average (estimated)		12				22				20				18		

SHIPBUILDING AND MISCELLANEOUS.

No figures are available showing the wastes associated with shipbuilding and other miscellaneous wood-using industries. In some of these industries—for example, in the manufacture of spools, shuttles, toys, etc.—the percentage of waste is very high, but since the relative quantity of material consumed by them is so small, they have little economic significance. It is safe, however, to assume that at least 15 per cent is wasted, representing an annual loss of approximately 157,000,000 board feet.

A general summary of the foregoing discussion is shown in Table IX:

Table IX.

Industry.	Estimated consumption, 1907, millions board feet.	Average percentage of waste.	Annual waste, millions board feet.
Building trades	24,150	15	3,600
Furniture	6,840	25	1,710
Boxes	3,460	20	692
Railway and transportation companies	2,820	10	282
Vehicle and implement	1,930	25	482
Shipbuilding and miscellaneous	1,046	15	157
Total or average	40,246	17	6,923

This total waste of 6,803,000,000 board feet represents 17 per cent of the lumber cut of 1907. It is made up mostly of sawdust, shavings, and small blocks, and nearly all of it is burned under factory boilers or as kindling wood; so in the true sense of the word it is not actually wasted, but merely serves a lower purpose than that for which the lumber was manufactured.

SUBSTITUTES.

The wastes due to improper use of lumber are undoubtedly great, but they are difficult to define or to study statistically. A brief review, however, of materials being substituted for lumber may prove helpful in suggesting what these wastes are and to what extent their elimination will diminish the annual consumption of lumber.

BUILDING TRADES.

The enormous supply of building stones and other raw material used in the manufacture of brick, concrete, etc., undoubtedly insures a very rapid decrease in the use of lumber as a building material. This tendency is already very marked in most of the large cities, and when it is remembered that the building trades consume 60 per cent of the entire lumber production, it seems that they offer the best field for decreasing the present enormous consumption.

RAILWAY AND TRANSPORTATION LINES.

Railroads are already using steel to a large extent in car construction and its use for this purpose is constantly increasing. It is almost universally used in car underframes and, to an increasing extent, for the bodies of both freight and passenger coaches. The Pennsylvania Railroad Company estimates that the total weight of wood in one of its modern passenger cars is not over 400 pounds, while many hoppers and other types of freight cars are built entirely of steel. On practically all of the well-established roads steel and concrete are being used for bridges in all new work except where such work is of a temporary character, and it is the general policy to replace wooden bridges with concrete and steel as rapidly as funds will permit.

FURNITURE INDUSTRY.

In the furniture industry brass and iron beds are to a large extent, used in the place of wooden ones. One manufacturer estimates that approximately 50 per cent of the beds now manufactured are of metal. Some restaurant tables are made with iron or wire supports, and pressed steel desks finished in wood, as well as steel typewriter chairs, and steel file cases are coming into use for office purposes.

PACKING BOXES.

The use of veneer and pulp board promises to diminish the amount of lumber required by the box industry and the tendency to adopt standard sizes is doing a great deal to increase the life of the packing box by making it available for reshipments. In general, however, wood in some form seems to be best adapted to the requirements of this industry.

VEHICLES AND IMPLEMENTS.

On account of the increasing scarcity and consequent high price of woods, such as hickory and oak, commonly used by vehicle makers, many substitutes have been tried. The substitution of metal for wood in vehicle construction is practiced to a limited but slowly increasing extent. Steel for axles, rims, hubs, and wire for spokes and sheet iron for body paneling are used. Metal paneling, however, has the drawback of bending easily. Endeavors to make such substitutions are very often unfavorably received by wagon users on account of the rigid and unyielding character of steel construction.

SHIPBUILDING AND MISCELLANEOUS INDUSTRIES.

Steel is rapidly becoming the exclusive material for constructing the hulls of all kinds of water craft, and such materials as pulp fiber, papier-maché, and various metals are rapidly supplanting lumber for such articles as buckets, toys, artificial limbs, etc.

It thus seems quite possible for the country to adapt itself to a per capita lumber consumption not more than one-half as great as at present.

TAXATION OF TIMBER LANDS.

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Chapter I.

INTRODUCTORY.

I. GENERAL PRINCIPLES OF TAXATION.

It is safe to say that nowhere in the whole domain of applied economics do we find such general confusion and such wide discrepancy between principle and practice as in the field of taxation. As an introduction to the study of timber-land taxation, it will be wise to lay down at the outset certain principles of taxation which are fundamental and generally accepted.

Every government requires some revenue in order to carry on its necessary functions. In modern States this revenue comes in the main from taxation. This is particularly true of the United States, where other forms of revenue are relatively insignificant.

Taxation necessarily involves sacrifice on the part of the taxpayer. This sacrifice is justified on the ground of the benefit to the public resulting from the operation of government functions. This principle also is the only correct guide to the proper amount of taxation. So long as the benefit to the public as a whole through the use of wealth by the State is greater than if this wealth were used by the individuals from whom it is taken, the imposition of taxes is justified. Otherwise, taxation is excessive.

The purpose of taxation is to obtain revenue. Incidentally, however, the taxing power has almost universally been used to accomplish certain other desired ends. Well-known illustrations are our liquor-license system, our protective tariff, the federal tax on the notes of state banks, etc. Where such a programme unquestionably increases the public welfare, there would seem to be no objection on the ground of principle. In the same way, taxation at a reduced rate or complete exemption may sometimes be granted in cases where an undoubted benefit to the community will result. Obviously such uses of the taxing power are peculiarly open to abuse and should be strictly limited.

In apportioning the burden of taxation among the citizens, it is a truism to say that taxation ought to be just. It is by no means so easy to define clearly what we mean by justice, or to discover what particular method of apportionment will best secure our ideal. The simplest method is equal apportionment; that is, an equal burden on every citizen. This crude plan has prevailed in primitive times, and it is conceivable that under certain conditions it might work fairly well. Just as soon, however, as the most primitive conditions are past, the unequal burdens caused by such apportionment become intolerable.

A second plan of apportionment is based upon the benefit theory. This plan attempts to collect from each citizen a payment in proportion to the particular benefit received by him on account of government services. But the benefits of government are mainly general. How then shall we measure the benefit to any particular citizen? Those who advocate this theory have generally gone on the assumption that the main function of government is to give protection to life and property. It is therefore assumed that, since the benefit of protection to life may be considered equal and the benefits to property proportional to the amount of the property, a correct apportionment of taxation would require an equal poll tax, with the remaining burden of taxation apportioned among the citizens according to the amount of property owned by each. This is in brief the idea of the benefit theory, a theory which is held in a vague sort of way by many people, and has been rather tenaciously adhered to by the legal profession in the United States.

The benefit theory is based on a number of erroneous premises. In the first place the function of government is not wholly the protection of life and property. Very many functions are performed by every modern State. Examples in the United States are too numerous and self-evident to require mention. There is therefore no ground for the assumption that the benefits derived from government are in proportion to property. As a matter of fact, the persons who are most dependent on governmental services are probably the poor and weak. The rich man is able to defend himself and to protect his property by private servants, watchmen, insurance, etc. In brief, the benefit theory would be unjust and impossible to apply. Among economists and students of public finance it has little standing to-day.

The third theory of apportionment is the so-called contributory theory or apportionment according to ability. The proposition here is to apportion the burden of taxation among the citizens according to each one's ability to pay. It is recognized that the benefits derived from government are general rather than particular, and it is maintained that the necessary expenses should be covered by contributions from all the citizens toward a common end in which all are interested. An analogy commonly referred to is the method of paying the expenses of a church or social club. Put in negative terms, the theory of ability means an apportionment which would result in equal sacrifice. The ability theory is undoubtedly the correct theory of apportionment, and the one that is coming to be generally accepted in theory and practice.

The question still remains as to what is the measure of ability or sacrifice. Ability and sacrifice are psychological conceptions, but the tax administrator must have some definite, tangible basis of apportionment. It is generally agreed that ability is to be measured in some way by the possession of wealth. Wealth exists in two forms: Either as capital, that is, an existing fund of wealth at a particular time; or as income, that is, a flow of wealth or of the services of wealth during a certain interval of time. Tax systems in general may be separated from each other as they apportion the burden, either according to capital or according to income. European countries in general apportion taxes according to income, whereas in the United States the general basis is the possession of capital or property.

II. THE GENERAL PROPERTY TAX IN THE UNITED STATES.

The basis of American state and local taxation is the general property tax. The theory of the general property tax contains two leading propositions: First, that property is a fair index of tax-paying ability, and second, that this index is capable of being estimated. Neither of these premises is correct. The general property tax is one of the oldest forms of taxation. It has always been the chief reliance of the American States and towns. Under the conditions prevailing in the colonial period the theory on which the tax is based was not so far from the facts, and the tax worked fairly well. The colonists were engaged mainly in agricultural pursuits, with some simple manufacturing industries and commercial enterprises. The bulk of the wealth consisted in lands, buildings, and agricultural stock and implements. Such property is easily located and its value capable of fairly accurate determination. Moreover, the relative economic position of different individuals bears a fairly close relation to their possessions. Under such conditions, the general property tax works well; assessment is fairly simple, evasion is difficult, and substantial justice is likely to be secured.

At present conditions are entirely changed. The bulk of wealth is no longer in real estate and visible personalty. To-day a large part of our property consists in stocks and bonds and other intangible evidences of wealth. Under a general property tax every individual is assumed to be assessed according to his total possessions, tangible and intangible. As a matter of fact, intangible personalty very largely escapes. In other words, the general property tax is unsuited to modern conditions. We need not describe the well-known result. Every one is familiar with the practical administration of the general property tax, and the ease with which taxes are evaded is notorious. The tax runs counter to two of the strongest motives to human action, the love of gain and the dislike of publicity. Since evasion is so easy and the motives to it so strong, it is no wonder that the administration of the general property tax has become a farce.

It is often stated that the failure of the general property tax is due entirely to administrative defects; that the tax is correct in theory and would work well if properly administered. This is not true. A general property tax is wrong in principle, and would lead to injustice and inequality even were it possible to administer it perfectly. In other words, the first premise of the general property tax is also false. Property is not a fair index of ability to pay taxes. An illustration of this will appear in the chapter on "The real economic problem of forest taxation."[a]

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[a] See Chapter V, p. 611.

In conclusion, the general property tax is a failure, historically, theoretically, and practically. Gradually the public is coming to a realization of this fact. Already many of the States have abandoned it in particular cases where its failure has become intolerable, as in the case of railroads, banks, and other corporations. We have practically, though not admittedly, given up the attempt to tax intangible personalty. A growing demand is in evidence for the giving up of the State's share in the general property tax, leaving it solely to the towns and counties. In these and other ways the movement away from the general property tax is unmistakable. In its adherence to this discredited tax the United States stands almost alone to-day. Other countries generally abandoned it long ago. Income, not property, should be the basis of any correct tax system.

Chapter II.

FOREST TAXATION IN THE UNITED STATES: THE LAWS.

Timber lands are taxed to-day under the general property tax in every State and continental Territory of the United States, generally in exactly the same manner as other kinds of wealth. In only twelve States[a] is any special consideration given to timber lands in the tax laws. Four other States[b] make provision for bounties for timber planting and cultivation, though these bounties have no connection with the taxation of the land or trees. Two States,[c] included, however, in the first group mentioned above, attempt to encourage the planting and cultivation of trees by offering prizes, without any reference to taxation. In all of the other thirty States and in the two Territories timber lands receive no special consideration.[d]

I. TAX EXEMPTIONS AND REBATES, AND BOUNTIES DEDUCTED FROM TAXES.

The twelve States whose tax laws make special reference to timber lands attempt to encourage the planting and cultivation of trees or the general practice of forestry by certain concessions in taxation. These concessions take the form of entire or partial exemptions from taxation, of rebates of part of the taxes, or of bounties to be deducted from the taxes.[e] The method usually employed is that of exemption. The plan of a rebate is used by New Hampshire; North Dakota uses bounties, while Wisconsin uses both exemptions and bounties. These exemptions, rebates, or bounties are granted to owners of timber lands in consideration of the planting, cultivating, growing, or protecting of trees, usually in accordance with regulations specified in the statutes, or under the direction of some state officer or board. In eight of the States the law applies only to plantations, and in five

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[a] Alabama, Connecticut, Iowa, Maine, Massachussetts, Nebraska, New Hampshire, North Dakota, Rhode Island, Vermont, Washington, and Wisconsin.

[b] Illinois, Kansas, Minnesota, aid Wyoming.

[c] Massachusetts and Vermont.

[d] For a list of these States and Territories, see appendix to Chapter II, p. 587.

[e] An abstract of the statutes in each of these States will be found in the appendix to Chapter II, p. 587.

States the land must not be wooded at the time of planting or growing the trees. In one State—Connecticut—the exemption applies only to land "not theretofore woodland."

The commonest form of tax concession consists of a complete exemption from taxes on the land and trees for a definite period of time, ranging from five to thirty years. The exemption begins either immediately after the land has been planted or set aside for the growth of trees, or after a certain period, measured either in years or in the growth of the trees.

In other States the concession is by means of a rebate of part of the taxes for a certain number of years (New Hampshire)[a] or by means of a bounty of so many dollars per acre to be deducted annually from the taxes on the land. (North Dakota and Wisconsin.)

In other States the exemption applies to the value of the trees only. (Nebraska and Washington.)

Iowa grants partial exemption to forest and fruit tree reservations by an arbitrary assessment of the land at $1 per acre.[b] Iowa also exempts from assessment the value of all planted trees.

II. BOUNTIES WITHOUT REFERENCE TO TAXATION.

In four States the attempted encouragement to forest planting and cultivation is by means of bounties having no connection with taxation. Strictly speaking, these laws do not belong in a study of taxation. However, since their general purpose is the same as the tax laws described above, and since they have some other points of resemblance to those laws, it has seemed worth while to mention them here for the sake of completeness. In only one of these cases (Minnesota) is a bounty actually offered by the State. The other three States merely give permission to the county commissioners to offer limited bounties.[c]

III. PRIZES.

For the sake of completeness we also mention the two States which provide by law for the offering of annual prizes to encourage the planting and cultivation of trees. The competitions are administered and the premiums granted through associations devoted to agriculture, etc., in the State, and funds are appropriated annually by the State for this purpose. In Vermont the law applies only to maple-sugar products.[c]

IV. CRITICISM.

None of these schemes of exemptions, rebates, bounties, and prizes has touched the real problem of forest taxation. Obviously, laws giving occasional small prizes for the best examples of tree plantations, hedge fences, etc., can have no far-reaching effects on the burdens of taxation. The same is true of the bounty laws of Illinois, Kansas, and Wyoming, which merely permit the several counties to grant small bounties for a few years. The Minnesota bounty law is the only one that has produced any results. Up to 1906, $440,000 had been spent by the State for this purpose, as a result of which it is claimed that some 50,000 acres have been forested.[a] If this result has indeed been accomplished it has been at a tremendous cost. Evidently we will not find a solution to the problem here.

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[a] Pennsylvania's rebate laws have recently been declared unconstitutional.

[b] Indiana formerly had a similar law, but it has been declared unconstitutional.

[c] An abstract of these laws will be found in the appendix to Chapter II, p. 587.

Something more might perhaps be expected of those laws which really give some abatement of the burden of taxation by means of exemptions, rebates, and bounties. Yet here also we find that practically no results of importance have been produced. Massachusetts has had an exemption law in force ever since 1878. A legislative committee in 1906 reported that this law "has been a failure, as practically no planting has been done under it."[b] One of the members of this committee reports that he could find only 16 acres in the State that had been affected by the law since 1878.[c] With regard to the rebate law of New Hampshire, the state forestry commission reports that "This abatement provision, although 3 years old, is not widely known among landowners, and has so far been inoperative."[d] In Connecticut, the exemption law has been similarly ineffective. Similar reports come from the other States where these schemes have been in operation long enough to have produced any results. The conclusion that these laws have produced no important results is confirmed by the testimony of all who have investigated the subject.[e]

This lack of results may be explained in part by certain very important defects in these laws. In the first place, the common restriction of the tax abatement to plantations, and the further restriction in many cases to land other than woodland, in large measure destroy the usefulness of the laws at the very beginning. The real problem is in connection with, not the planting of new forests on agricultural or other land, but the protection and preservation of our present forests.

Moreover, the regulations regarding planting, thinning, etc., are not drawn in accordance with scientific forestry principles. Often the number of trees required per acre is too large. When the planting is restricted to certain specified kinds of trees, the list is not always well chosen, valuable species being often omitted. The proper thinning of the growing forest and the most profitable use of the forest are often interfered with by the requirements of the statutes.

Again, the burden of the tax reduction is not provided for or not properly placed. The justification of the concession to the timber owner lies in the advantage to the State in general. Yet the particular locality in which the land is located is called upon to bear the whole or the principal part of the burden of a diminished revenue. What the timber owner gains must be made up by heavier taxes on other local property. This point was evidently not considered at all in framing these laws.

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[a] Report of the Massachusetts legislative committee of 1905 to consider the laws relative to the taxation of forest lands, p. 10.

[b] Report of the Massachusetts legislative committee of 1905 to consider the laws relative to the taxation of forest lands, p. 17.

[c] Akerman. Southern Woodlands. June, 1908, p. 39.

[d] New Hampshire Forestry Commission Report, 1905–6, p. 204.

[e] Cf. Pennsylvania Department of Forestry Report, 1905–6, pp. 15–19; the Massachusetts Report referred to above; etc.

Certain local assessors have taken this matter into their own hands, and have adopted the custom of adding enough to the assessment of some other property of the timber owner to make up for the reduced taxes on his timber lands. In this way they protect the local revenue, and also defeat the whole purpose of the law.[a]

The actual financial consideration in these laws is really not very great. Generally the exemption is limited to a rather short period of time, after which the land and trees are again subject to the general property tax. Moreover, the abatement comes in the years when the trees are small and when the taxes would not be very heavy anyway. The remission of taxes resulting from these laws is small when compared with the expense of planting trees and holding them to maturity.

In short, these laws are based on no sound principles either of forestry or of finance.

It is not to be inferred that the failure of these laws to produce important results is wholly due to the defects just described. It is very doubtful whether any law of this character, no matter how scientifically drawn and administered, short of a complete exemption of growing timber, can have any great influence on forests and forestry.

The effects of all these laws on the actual burden of timber land taxation may be regarded as negligible. We accordingly return to the statement with which this chapter started, that timber lands are taxed in the United States, with few and unimportant exceptions, in exactly the same manner as other wealth subject to the general property tax.

APPENDIX.

LAWS RELATING TO FOREST TAXATION IN THE UNITED STATES.

I. GENERAL SUMMARY.

Special consideration is given to timber lands in the tax laws of 12 States, as follows: Alabama, Connecticut, Iowa, Maine, Massachusetts, Nebraska, New Hampshire, North Dakota, Rhode Island, Vermont, Washington, and Wisconsin.

The States which provide for bounties, without reference to taxation, are four in number, as follows: Illinois, Kansas, Minnesota, and Wyoming.

The States which provide for prizes, without reference to taxation, are two in number, as follows: Massachusetts and Vermont.

No special consideration is given to timber lands in 30 States and 2 Territories, as follows: Arkansas, California, Colorado, Delaware, Florida, Georgia, Idaho, Indiana, Kentucky, Louisiana, Maryland, Michigan, Mississippi, Missouri, Montana, Nevada, New Jersey, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, West Virginia, Arizona, and New Mexico.

This appendix presents an abstract of all state laws which offer inducements to the planting and cultivation of trees by means of tax exemptions or reductions or by other financial considerations. They are arranged according to their subject matter in three groups: (1) Those laws which grant exemptions or rebates from taxation, or bounties to be deducted from the taxes; (2) those laws which grant bounties without reference to taxation; (3) those laws which provide for prizes for tree planting and cultivation, without reference to taxation. Strictly speaking, only those laws in the first group belong to the discussion of taxation. However, the other laws have the same general purpose, and occasionally some other points of resemblance to those in the first group, and it has seemed worth while to include them for the sake of completeness.

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[a] Elliott. Forestry and Irrigation, April, 1906, p. 178.

The following abstract covers the main features of the statutes, but omits such details as the number of trees required per acre, regulations as to thinning, etc., which are generally provided for in the laws. The abstract is intended to cover all laws in the States and Territories of the continental United States in effect in October, 1908, but it is possible that some enactments of 1908 may have been omitted. Laws clearly held unconstitutional have been omitted.

II. TAX EXEMPTIONS, REBATES, AND BOUNTIES DEDUCTED FROM TAXES.

1. Alabama permits the owner of land which has been denuded of trees, or the assessed value of which does not exceed $5 per acre, to make a contract with the commission of forestry agreeing to plant or grow and maintain timber trees on such land for ten years, under the direction of the commission, in return for which the land is exempt from taxation for a period of ten years. (Laws of 1907, Sp. Sess., No. 90, H. 67.)

2. The Connecticut law applies to any land, not exceeding in value $25 per acre, and not previously woodland, which the owner plants to certain specified kinds of timber trees. After the trees have grown to the average height of 6 feet, the owner may obtain exemption from taxation for a period of twenty years. (General Statutes, Revision of 1902, sec. 2320.)

3. The Maine law applies to "cleared land or lands from which the primitive forest has been removed," which the owner plants or sets apart for the growth of forest trees. After the trees have been properly maintained for three years, the owner may obtain exemption from taxation for twenty years. (Laws of 1907, ch. 169.)

4. The Massachusetts law applies to plantations of certain specified kinds of timber trees, upon land which at the time of planting was not "woodland or sprout land, or land containing more than 600 standing trees to the acre," and not worth more than $10 per acre. After the trees have grown in height 2 feet on the average, the owner is entitled to exemption from taxation for ten years. (Laws of 1908, ch. 120.)

5. The Rhode Island law applies to plantations of certain specified kinds of timber trees upon land worth not more than $25 per acre. Exemption from taxation is granted for a period of fifteen years from the time of planting, provided the land is planted and managed under a forest-working plan approved by the state commissioner of forestry. Not more than 300 acres owned by a single person or corporation may be thus exempted from taxation. (Laws of 1908, ch. 1581.)

6. The Vermont law allows to uncultivated lands, planted to timber or forest trees and cared for under the direction of the forestry commissioner, exemption from taxation for ten years beginning April 1 of the second year after the planting. (Public Statutes, 1906, sec. 368–370; 496, Sub. XIV.)

7. The Wisconsin law applies to lands not within 2 miles of any incorporated city or village except upon written approval of the state forester, and not worth more than $10 per acre. If the owner of such lands sets apart any portion, not exceeding 40 acres, for forest culture and plants it with timber or forest trees, and properly maintains the trees, he is entitled to exemption from taxation for a period of thirty years from the time of planting. (Laws of 1907, ch. 592.) Wisconsin also provides that when tree belts of certain specified character are planted and properly maintained, the land on which they are planted shall be exempt from taxation until the trees reach the height of 12 feet, after which the owner is entitled to an annual bounty of $2 per acre, which bounty is deducted from the taxes assessed on the land. (Wisconsin Statutes of 1898, sec. 1469–1471.)

8. Iowa has an exemption law somewhat different from the others. The Iowa statute provides for the setting apart of so-called forest or fruit-tree reservations in private ownership, with certain restrictions as to area of the reservation, and number, species, and care of the trees. Such reservations are assessed for taxation at $1 per acre for a period of eight years from the time of planting. Moreover, in all cases where trees are planted, the assessed value of the land is not to be increased on account of the value of such trees. (Code of Iowa, Supp. of 1907, sec. 1400c–1400p.)

9. Nebraska has a statute providing that "The increased value of lands, by reason of live fences and forest trees grown and cultivated thereon shall not be taken into account in the assessment thereof." This law carries out a provision of the state constitution expressly permitting such legislation. (Compiled Statutes of 1881 with amendments to 1907, sec. 4934.)

10. Washington exempts from taxation "all fruit trees, except nursery stock, and forest trees artificially grown." (Pierce's Code of 1905, sec. 8595, sub. 5.)

11. New Hampshire allows to the owners of land planted with timber or forest trees the following rebate of taxes for a period of thirty years: For the first ten years after planting, a rebate of 90 per cent of all taxes assessed upon the land; for the second ten years, a rebate of 80 per cent, and for the third period a rebate of 50 per cent.[a] (Laws of 1903, chap. 124.)

12. North Dakota grants a bounty of $3 per acre for tracts of prairie land of 1 to 10 acres planted to any kind of forest trees and properly maintained. This bounty may commence one year after planting and is deducted annually from the farm taxes for a period of five years. A bounty is also granted for forest trees planted in hedge rows as boundary lines. The bounty is $2 for 80 rods of hedge row, paid annually for a period of five years. (Revised Codes of 1905, secs. 2082–2085.)

III. BOUNTIES WITHOUT REFERENCE TO TAXATION.

1. Minnesota gives a bounty of $2.50 "per acre for a period of six years" to any person who plants from 1 to 10 acres of prairie land with forest trees and properly maintains them. (Revised Laws of 1905, secs. 2391–2395.)

2. Illinois allows the county commissioners in any county to offer a bounty not to exceed $10 per acre annually for three years to any person who shall plant and properly cultivate 1 or more acres of forest trees. (Revised Statutes of 1908, chap. 136, secs. 1–4.)

3. Kansas also permits the county commissioners in any county to offer a bounty "not to exceed $10 for five years for each acre" to any person who plants and properly cultivates forest trees. The trees must have been kept in thrifty condition for five years before the bounty is payable. (Dassler's General Statutes of 1905, secs. 8605–8608.)

4. Wyoming has a similar law allowing the county commissioners in any county to offer a bounty "not to exceed $10 for five years for each acre" to any person who shall plant and properly cultivate forest trees. The trees must have been kept in thrifty condition five years before the bounty is payable. (Revised Statutes of 1899, secs. 2645–2648.)

IV. PRIZES.

1. Massachusetts requires that every incorporated agricultural society which receives a bounty from the State shall annually offer premiums to encourage the raising and preservation of forest trees. (Revised Laws of 1902, chap. 124, sec. 10.)

2. Vermont provides an annual appropriation of $500 for the Maple Sugar Makers' Association of the State and requires that at least $100 annually shall be spent by the association in premiums for the best maple-sugar products. (Public Statutes of 1906, secs. 340–341.)

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[a] Pennsylvania has allowed a rebate of 80 per cent of all taxes on land containing forest trees with certain restrictions as to number and size of trees, etc., provided that the rebate shall not exceed the sum of 45 cents per acre. (Laws of 1905, chap. 88.) Another Pennsylvania law formerly provided that lands planted to forest trees or maintained with sprout, forest or timber trees, with certain restrictions, shall receive a rebate of 80 per cent of all taxes for a period of thirty-five years from the time the land has been planted or maintained, provided that the rebate shall not exceed 45 cents per acre. (Laws of 1905, chap. 179.) The above statutes were enacted in 1905, taking the place of similar laws which had been in force since 1887, but both statutes have recently been declared unconstitutional. (Tubbs *v.* Tioga County, 32 Penn. County Court Reports, p. 504.)

CHAPTER III.

FOREST TAXATION IN THE UNITED STATES IN PRACTICE.

I. ADMINISTRATION.

The foregoing discussion of special statutes relating to the taxation of timber lands has shown how little real importance they possess. None of the statutes providing for exemptions, rebates, bounties, and prizes has modified to any extent the burden of the general property tax, or had any important effects on timber lands and the practice of forestry. In studying the practical administration of forest taxation, we are really studying the general property tax itself. The following discussion of methods of administration is therefore very brief, attempting only to give a general survey of the actual administration of the general property tax under which forest lands are taxed.

The administration of the general property tax, being in the hands of local officers, is not exactly the same in any two States or even in any two towns. No attempt will be made here to describe peculiarities of local administration. Certain broad features, however, mark the administration of the general property tax everywhere.

Assessment is in the hands of local officers representing usually the towns but frequently the counties. It is the business of the assessors to make a valuation of the property of every taxpayer in the town or county. The assessor is ordinarily a man possessing no particular technical skill and having no particular facilities for ascertaining the value of property. He is obliged to depend upon the taxpayer's declaration, upon hearsay evidence of one sort and another, and upon occasional examinations of the property which must be at best superficial and inaccurate. The methods of assessment are usually lax. Personal examination of forest lands is made only occasionally at more or less long intervals. Very commonly the tax assessor makes up his books by merely copying from the books of the year before. Even where the assessor uses the best possible methods and the greatest care, the result is bound to be largely a matter of personal judgment. The opportunity for the exercise of personal prejudice is obvious, as is also the opportunity for dishonest collusion with the taxpayer. It should be said, however, that testimony is almost universal to the fact that the local assessors are as a rule honest and faithful officers who endeavor to perform their duties conscientiously and to the best of their ability. The usual motive to undervaluation—the desire to escape as much as possible of the town's burden of State and county taxes—is present wherever the State and county share in the proceeds of the general property tax. This hit-or-miss method of assessment produces the well-known results of inequality, undervaluation, overvaluation, and general confusion. As a rule all property is assessed considerably below its true market value, although this is contrary to law. Assessors usually adopt some fixed ratio of assessed to true value.

The collection of the tax on timber lands is also in the hands of local officers, and involves nothing of special importance in this connection. The rate of the tax is made up of the state, county, and town rates, with sometimes other rates for schools, roads, etc. In a number of States, however, the general-property tax is left to the local divisions, in which case there is no state rate. The tax rate varies from place to place. The burden of taxation on any piece of land depends on the tax rate combined with the ratio of assessed to true value.

II. THE BURDEN OF TAXATION.

It is important to know just what is the actual burden of taxation upon timber lands. To thoroughly answer this question would necessitate a detailed study of forest taxation in every State, and indeed in every town where forests are important. This study will take time. Only a beginning has been made as yet. Nevertheless, enough evidence is at hand to enable us to draw some conclusions. These conclusions are, however, only tentative and may possibly have to be modified after further investigation. They are based on (1) an extensive correspondence with tax officials, state foresters, lumber owners, and others; (2) special local investigations made by members of the Forest Service; (3) miscellaneous evidence from forestry journals, lumber-trade journals, the publications of the United States Forest Service, and the several state foresters, and from numerous other sources.

From this evidence, so far as it goes, the following conclusions seem to be warranted:

1. The valuation of forest lands is made in the most haphazard way, resulting in the greatest uncertainty and inequality. For example, a wood lot in New Hampshire was purchased for $1,000. Its assessed value, which had been $400, was immediately raised to $3,000, or three times the purchase price. The tax rate in this town was 1.85 per cent. Assuming that the purchase price represented the true value of the property, it was required to pay a tax every year of 5½ per cent of its value. In this particular case the owner made no complaint, for the reason that he believed this excessive tax was counterbalanced by undervaluation of some of his other lots, an interesting commentary on the results of local assessment.

As an example of undervaluation we may cite another piece of timber land in New Hampshire which was sold for $15,000. Its assessed value at the time was $500, or one-thirtieth of the selling price. Even after the sale, its assessed value was raised only to $1,100.

Here is an interesting example of unequal assessment. Two adjoining tracts in New Hampshire were estimated by the Forest Service investigator to be of about equal value. The first, which was if anything the more valuable of the two, was assessed at $500; the second at $3,500, or seven times the other.

2. The above examples are extreme cases, though similar cases are common enough. What we are more especially interested in is the prevailing burden of taxation in the general run of ordinary cases. The facts seem to be as follows: In some States or regions the prevailing burden of taxation on timber lands is undoubtedly very heavy. There is a good deal of evidence showing excessive taxation of timber lands in parts at least of the States of Michigan, Wisconsin, Minnesota, and the States of the Pacific coast. On the other hand, there are States where the prevailing taxation of timber lands is decidedly lenient. Individual cases of unduly lenient and excessively heavy taxation are common, probably everywhere. Leaving out of consid-

eration individual cases, and without going into local conditions, it is safe to say that in general timber land, like most other property, is grossly undervalued by the assessors. Probably, until very recently at any rate, timber land has been assessed relatively lower than agricultural land. This assessment is combined with a high tax rate; that is, a rate which would generally result in excessive taxation if the property were assessed at its true value. As a general rule, however, due to the prevailing underassessment and the lax administration of the laws, timber lands are not subjected to an excessive burden of taxation. In the great majority of cases investigated the annual tax was less (usually very much less) than 1 per cent of the true value.

3. A third conclusion that stands out distinctly is that there is at present in many places an unmistakable tendency toward heavier taxation of timber lands. This tendency is seen especially in those regions where forests have heretofore been admittedly taxed very gently, such as the wild lands in the unincorporated parts of Maine and New Hampshire. Here there is considerable complaint of the escape of wealthy timber owners from their just share of taxation, and a growing demand for amendment to the statutes which will put a heavier tax upon these lands. On the other hand, the movement toward heavier taxation is seen in the common tendency to value timber lands more accurately and enforce the existing laws more strictly. It should be remembered, however, in connection with the tendency to increase the assessed valuation of timber lands, that there has been a very great increase in the real values of lumber and timber lands within recent years.

The evidence on this subject, though far from complete, is still quite extensive. Part of this evidence is presented in the appendix to this chapter, together with some analysis and discussion.[a] Some further incidental light on this problem may be obtained from the testimony of lumbermen presented in the appendix to the next chapter.[b]

APPENDIX.

EVIDENCE AS TO BURDEN OF TAXATION ON FORESTS.

I. SOURCES OF EVIDENCE.

The conclusions in the text regarding the present burden of taxation upon forests in the United States are based upon a mass of evidence, the principal sources of which are the following: (1) Letters from local tax assessors and other officers received in reply to a schedule of inquiry sent out by the Forest Service under the writer's direction; (2) letters from state foresters, tax commissioners, and other authorities received in reply to a letter of inquiry sent out by the International Tax Association; (3) special local investigations made by members of the Forest Service; (4) miscellaneous evidence from forestry journals, lumber-trade journals, and publications of the United States Forest Service and the several state foresters; (5) an extensive correspondence by the Forest Service and by the writer; and (6) interviews with a number of persons having special knowledge of the subject. In this appendix is presented, with some analysis and discussion, some of the more important parts of this evidence.

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[a] See Appendix to Chapter III, p. 592.

[b] See Appendix to Chapter IV, p. 608.

II. NEW HAMPSHIRE.

The State for which we have the best evidence is New Hampshire. A careful study of taxation of timber lands in this State has been made by Mr. J. H. Foster, of the Forest Service, and a large amount of valuable material gathered. This material makes it possible to present a fair idea of the actual burden of taxation borne by timber lands in New Hampshire.

For this purpose the State naturally divides itself into two parts. The southern part is the prevailing wood-lot section; in general, the lots are not of great size and they are situated in well-settled incorporated towns. In the north, although here, too, we find many wood lots, a large part of the forests is owned by lumber and paper companies, institutions, estates, and persons of large means. Much of this land is located in unincorporated places.

The average tax rate for all the incorporated towns of the State in 1907 was 1.99 per cent.[a] For each county the average rate for the incorporated towns is shown in the following table:[b]

New Hampshire tax rates, 1907.

	Per cent.
Average for the State	1.99
Rockingham County	2.11
Strafford County	1.95
Belknap County	2.29
Carroll County	1.95
Merrimack County	2.02
Hillsboro County	1.87
Cheshire County	1.77
Sullivan County	2.09
Grafton County	2.23
Coos County	2.14

The prevailing rates in the several towns lie between 1.5 and 2 per cent. Of the 235 towns in the State, 113, or 48 per cent, have rates ranging from 1.51 to 2; 45 towns, or 19 per cent, have rates from 1 to 1.5; and 54 towns, or 23 per cent, have rates from 2.01 to 2.5; 21 towns, or 9 per cent, have rates above 2.5. The lowest rate in any town is 0.7, and only one other town has a rate below 1 per cent. The highest rate is 3.28, and only one other town has a rate above 3 per cent. The rate in the unincorporated places was 0.4 in 1907. These places have a very low rate on account of not having to pay town taxes.

The valuation of timber lands is made by local assessors in the incorporated towns and by the state board of equalization, with the assistance and advice of the county commissioners in the unincorporated places. Throughout the State timber lands are assessed far below their true value. From several hundred examples investigated, the following cases are given. These are cases in which the true values were ascertained with some accuracy.

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[a] Valuation and Taxation of the State of New Hampshire for the Year 1907; Compiled by the Secretary of the State Board of Equalization, p. 83.

[b] Ibid.

Assessed valuation and true value per acre, 1908.

	Assessed valuation.	Estimated true value.	Percentage of assessed to true value.
CENTRAL WOOD-LOT REGION.			
Case 1	$6.50	$30.00	21.7
Case 2	53.00	104.00	51.0
Case 3	10.00	50.00	20.0
Case 4	50.00	64.00	78.1
Case 5	3.00	30.00	10.0
Case 6	39.00	60.00	65.0
Case 7	8.50	22.00	38.6
Case 8	3.00	50.00	6.0
Case 9	37.50	70.00	53.6
SOUTHERN WOOD-LOT REGION.			
Case 10	50.00	80.00	62.5
Case 11	13.00	23.00	56.5
Case 12	40.00	100.00	40.0
Case 13	16.00	40.00	40.0
Case 14	35.50	150.00	23.6
Case 15	18.00	52.00	34.6
Case 16	95.00	150.00	63.3
Case 17	13.50	34.00	39.7
Case 18	11.50	36.00	31.9
Case 19	2.30	10.00	23.0
Case 20	30.00	50.00	60.0
Case 21	20.00	75.00	26.6
Case 22	54.00	90.00	60.0
Case 23	66.00	100.00	66.0
Case 24	57.00	128.00	44.5
Case 25	90.00	325.00	27.6
Case 26	50.00	60.00	83.3
Case 27	23.00	30.00	76.6
WILD LANDS IN SOUTHERN TOWNS.			
Case 28	5.00	40.00	12.5
Case 29	5.00	30.00	16.6
Case 30	23.00	66.00	34.8
Case 31	70.00	150.00	46.6
WILD LANDS IN NORTHERN TOWNS.			
Case 32	30.32	35.00	86.6
Case 33	4.70	35.00	13.4
Case 34	5.00	40.00	12.5
Case 35	11.61	50.00	23.2
Case 36	15.00	30.00	50.0
Case 37	7.00	35.00	20.0
Case 38	8.60	60.00	14.3
Case 39	7.00	40.00	17.5
Case 40	6.00	35.00	17.1
Case 41	6.00	60.00	10.0
Case 42	4.70	35.00	13.4
Case 43	15.00	60.00	25.0
Case 44	8.00	75.00	10.6
Case 45	4.00	20.00	20.0
Case 46	8.50	50.00	17.0
Case 47	3.00	10.00	30.0
WILD LANDS IN UNORGANIZED PLACES.			
Case 48	15.14	20.00	75.7
Case 49	10.85	25.00	43.4
Case 50	5.72	20.00	28.6
Case 51	10.25	25.00	41.0
Case 52	19.43	30.00	64.7
Case 53	2.50	30.00	8.3
Case 54	8.00	25.00	22.0
Case 55	17.39	25.00	69.5
Case 56	15.06	30.00	50.2

An analysis of these figures gives a fair idea of the prevailing undervaluation of timber lands throughout the State. There are 56 examples in all. The average ratio of assessed to true value is 37.7 per cent. The closest approach to true value was made in the case where the forest was assessed at 86.6 per cent of its estimated true value. The lowest assessed valuation is 6 per cent. Of the 56 cases only 16 were assessed above 50 per cent of their true value and 21 cases were assessed below 25 per cent. In round numbers, more than two-thirds of these 56 forest properties were assessed at not more than one-half of their true value; three-eighths of the properties were assessed at less than one-fourth of their true value; and the average assessment for all 56 cases was only a little more than one-third of the true value.

The assessment varies somewhat with the region. It is highest in the wild lands of the unorganized parts of the State and in the southern wood-lot region. Of the cases in organized towns, about three-fourths were assessed at not more than one-half their true value, nearly half at less than one-fourth their true value, while the average assessment for all cases was only a little over one-third of the true value. An analysis of the examples according to region is given in the table below.

Percentage of assessed to true value, 1908.

Region.	Number of cases.	Average.	Highest.	Lowest.	Cases above 50 per cent.	Cases below 25 per cent.
Central wood lot	9	38.3	78	6	4	4
Southern wood lot	18	48	82	23	8	2
Wild lands in towns of South	4	28	47	17	0	2
Wild lands in towns of North	16	21.8	87	10	1	12
Wild lands in unorganized places	9	46	76	8	3	1
All cases in towns	47	36.2	87	6	13	20
Total	56	37.7	87	6	16	21

Extending this investigation, by taking in a number of examples where the true value can not be accurately determined and yet may be roughly estimated, produces results which agree substantially with the above. An investigation of something over 100 examples of wood lots in southern New Hampshire, estimating the true values roughly but very conservatively, shows that in fully three-fourths of the cases the assessed valuation is not greater than half the true value. In one-third of the cases the assessed value is less than one-fourth of the true value. There are a few extreme cases, both of high and of low valuations, but only three or four cases where the valuation appears to exceed the true value. There are a good many more cases where the property is ridiculously undervalued.

A similar investigation of a number of examples of wild lands in towns of northern New Hampshire shows a still lower basis of assessment. Hardly any cases appear where the assessment is more than half the true value. About half the examples were assessed at less than one-fourth the true value, the other half being assessed between one-fourth and one-half of the true value. A large number of cases appear where the assessment is only 10 per cent of the true value or even less. These results agree with the figures above based on cases where the true values were more accurately determined.

Having before us the facts regarding the tax rate and the ratio of assessed to true value, we are in a position to determine the actual burden of taxation on the forests of the State. The average tax rate of the towns in 1907 was 1.99 per cent. The average ratio of assessed to true value in the examples from towns was 36.2 per cent. Combining these figures would show an average tax of 0.72 per cent of the true value, or a little less than three-fourths of 1 per cent.

Again, 48 per cent of the towns have tax rates from 1.5 and 2, and another 19 per cent have rates from 1 to 1.5. Also, three-fourths of the cases of taxation in organized towns showed assessed valuations of not more than half the true value. These figures furnish a fair presumption that a large majority of forest properties are taxed at something less than 1 per cent of their true value.

A more satisfactory way of approaching this question is by an analysis of all the individual examples where it is possible to combine the tax rate and the ratio of assessed to true value. From about 150 such examples the following results are obtained. These results are in some cases based on fairly accurate knowledge of true values; the majority are based on more or less rough estimates of true value.

Less than one-fifth of the cases show a tax rate exceeding 1 per cent of the true value. The other four-fifths may be divided roughly into three equal groups. About one-fourth of the cases show rates from one-half of 1 per cent to 1 per cent; another one-fourth shows rates from one-fourth to one-half of 1 per cent; while one-fourth again shows rates below one-fourth of 1 per cent. In slightly more than half the examples the taxes do not exceed one-half of 1 per cent of the true value. These examples also show the relatively lower burden of taxation in the northern part of the State, where in nearly three-fourths of the cases the taxes are not over one-half of 1 per cent of the true value.

In the unincorporated parts of the State timber lands are taxed very leniently. With a tax rate of only four-tenths of 1 per cent, it hardly requires further evidence to show that the taxes are not heavy, even though the property were assessed at its full value, which is rarely, if ever, the case. The ratio of assessed to true value is, indeed, relatively high in the unorganized places.[a] The nine examples given showed an average ratio of 46 per cent. This would give an average tax of a little less than one-fifth of 1 per cent of the true value. Only a few examples showing the true value are available. Of these, the large majority pay taxes which are less than one-fourth of 1 per cent of the estimated true value of the property.

Thus far the attempt has been made to present the general situation in New Hampshire with regard to the burden of the general property tax on forest lands. Extreme and peculiar cases have not been discussed; we have described rather the condition of the general run of ordinary cases. Needless to say, there are plenty of cases that are peculiar in one way or another, and a glance at a few individual examples, taken more or less at random, may bring out a number of important and interesting side lights on this subject.

Several examples show a decidedly small burden of taxation. One tract of 200 acres in the mountains of southern New Hampshire covered with mature spruce has been assessed for years at $1,000. Recently the tract was sold for $5,000 and ten days later for $8,000.

In a certain town a farmer owns a number of lots in different parts of the town, worth altogether about $40,000. Outside the farm on which he lives, he is assessed for only $1,200. Apparently the assessors know very little about his valuable wood lots.

A certain old farm of 209 acres in southern New Hampshire has been assessed for the last twenty years at $500. In 1906 the assessors decided that this was too low and raised the valuation to $1,000. Since then the farm has been sold for $13,000 and it is now being assessed for $10,000.

Another wood lot was assessed at $250. Some one complained that this lot was not being taxed enough and the assessment was raised to $1,200. Soon after a lumberman paid $6,000 for the timber alone, leaving the farm still worth as much as $1,200.

A valuable piece of timber land about which the assessors apparently had little information was sold to a lumber company for $15,000. Its assessed valuation at the time was $500. Even after the sale the assessed value was raised only to $1,100.

Some equally interesting examples show what is undoubtedly excessive taxation. A lot of 1,628 acres in northern New Hampshire was assessed in 1906 at $3,300 or about $2 per acre. Next year the valuation was raised to $3.42 per acre, and in 1908 was increased to $50,000, or an average of $30.32 per acre. The paper company which owns this tract has complained against this assessment, and it is said that they are willing to sell the tract for $10,000, or one-fifth its assessed valuation.

Four lots in a town of northern New Hampshire were assessed for a number of years at $700 each. The owner tried to sell the lots for this price, but was unable to find a buyer. They were finally sold for $500. As the tax rate in this town was 2.25 per cent, this means a decidedly heavy burden of taxation.

A water company in a town of southern New Hampshire is assessed $100,000 on 70 acres of land and improvements. The improvements are estimated as worth $60,000, leaving an assessed valuation of $40,000 on 70 acres of land, or an average valuation of $571.43 per acre. The tax rate in this town in 1907 was 1.55 per cent.

A wood lot in northern New Hampshire, containing 250 acres, was bought at auction for $1,400. Soon after the assessed valuation, which had been very low, was increased to $1,800. Part of the timber was then cut off and sold, but the valuation was further increased to $2,100. This property is probably not worth its assessed valuation. As the tax rate in the town is 2.95 per cent, this means a decidedly heavy tax.

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[a] See table above, p. 594.

A wood lot in southern New Hampshire was purchased for $1,000. It had previously been assessed at $400, but this valuation was immediately raised to $3,000 or three times the purchase price. The tax rate in this town in 1907 was 1.85 per cent. Assuming that the purchase price represented the real value of the lot, this lot is taxed over 5½ per cent of its value every year. In this particular case, the owner made no complaint, for the reason that he believed this excessive taxation was counterbalanced by undervaluation on some of his other lots.

The cases given above have illustrated not only the possibility of very heavy and very light burdens of taxation, but have also served to show the arbitrary and uncertain character of the prevailing methods of assessment. They show how eagerly the sale of a piece of property is seized upon by the assessors as evidence showing its value, which apparently had been only guessed at before. It may be worth while here to refer to some other examples showing the general character of assessment.

Two wood lots in southern New Hampshire were carefully examined and compared with each other. The lots were of the same general character, about equally distant from town, and apparently of about the same value; each was recorded in the tax books as containing 25 acres. One was assessed, however, for $800 and the other for $1,500.

Another example showing unequal assessment is that of a wood lot of 100 acres and an adjoining farm and wood lot in a town of southern New Hampshire. The 100-acre wood lot is probably somewhat more valuable than the adjoining farm and wood lot; yet the former is assessed at $500 and the latter at $3,500.

In some places the assessors purposely undervalue timber lands for the reason that the forests in the neighborhood of summer resorts add to the attractiveness of the region and therefore to the profits of the inhabitants. It is wished to encourage such natural advantages by a low burden of taxation. The evidence shows that in some towns such forest tracts are practically untaxed through the force of public opinion. For example, two lots in such a town were assessed at $500, while their true value is shown by their later sale for $5,800.

Reference has been made to the eagerness with which sales are seized upon by the assessors as giving evidence of the value of timber land. Two other examples of this may be of interest. A timber tract in southern New Hampshire was sold in 1905 for $12,000. Up to that time it had been assessed at $900. After the sale this valuation was raised to $4,000, still, however, only one-third of the purchase price. A wood lot which was sold in 1907 for $7,000 had been assessed up to that time at $500. After the sale the valuation was raised to $3,500. The owner complains that he is overtaxed in spite of the fact that his assessed valuation is only one-half the price paid for the land.

Almost every example of successive assessments for a number of years shows the striking tendency toward increased valuations during recent years. We may cite a few such cases by way of illustration.

A tract of 100 acres in Cheshire County, of which about 80 acres are covered with a good growth of pine, was assessed in 1897 at $1,000, in 1899 at $1,300, in 1900 at $1,600, in 1901 at $2,000, in 1902 at $2,300, in 1904 at $3,250, in 1905 at $4,500, in 1906 at $5,000,[a] and finally in 1908 at $7,000.

One of the most striking cases of increased valuation occurred in one of the upper Connecticut Valley towns. This town raised its valuation on timber lands $90,000 in 1908. Expert estimators were employed to value the timber. The valuations were considered decidedly lenient, yet the assessment of one company was raised from $3,050 to $16,000, that of another company from $5,000 to $50,000, while one small wood lot was raised from $250 to $4,000.

In a certain town of northern New Hampshire the total "nonresident valuations" of timber lands have been raised since 1892, as is shown by the following figures:

1892	$37,018
1902	43,980
1904	88,572
1905	112,368
1908	267,500

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[a] New Hampshire Forestry Commission, Report 1905-6, p. 206.

A tract of 10,000 acres in northern New Hampshire was valued in 1890 at $6,000, in 1895 at $10,000, in 1900 at $20,000, in 1905 at $30,000, and in 1908 at $60,000, a tenfold increase in eighteen years.

A certain tract in the unincorporated part of the State was assessed in 1902 at $200,000 and four years later for $325,000. In 1890 the valuation was only $25,000.

A certain city in southern New Hampshire undertook to assess its timber lands carefully after a thorough valuation by a board of experts. Having obtained as nearly as possible the true value of each lot, its assessed value was placed on the books at about 60 or 70 per cent of the estimated true value. The result of this method of assessment was to enormously increase the assessed valuations. Out of 24 examples taken from the tax books of this town only three cases appear where the increase was less than 100 per cent. In these cases the valuations were increased, respectively, 40 per cent, 66 per cent, and 66 per cent. In five cases the valuation was doubled, in five cases trebled, and in the other cases increased still more. In one case the assessment was eight times what it was before. This example is good evidence of the prevailing undervaluation of timber lands and of the result that would follow strict assessment according to true value, and it should be remembered that in this case the assessed valuation was purposely put at about two-thirds of the estimated true value.

In conclusion, this investigation of conditions in New Hampshire serves to demonstrate (1) that the assessment of timber lands is more or less arbitrary and uncertain, often being a matter of mere guesswork; (2) as a result there are many individual cases of ridiculously low valuation and some cases of excessive valuation; (3) that in the general run of cases the burden of taxation is decidedly moderate; (4) and, finally, that there is a tendency toward higher assessment and heavier taxes. These conclusions receive further support from the report of the New Hampshire Tax Commission of 1908.[a]

III. OTHER NEW ENGLAND STATES.

It is unfortunate that such extensive evidence as exists in the case of New Hampshire is not available from other States. It is hoped that as this study progresses similar material may be collected from at least all of the other important timber-producing States. For the present we must be content to draw what conclusions we can from the testimony that is available from other parts of the country.

Considerable miscellaneous evidence seems to warrant the conclusion that the general situation in Maine is substantially similar to that of New Hampshire. Here also we find a large territory which is not incorporated and has no town taxes to pay. The most important facts regarding the taxation of these lands are shown in the following quotation:[b]

"A late estimate places the total amount of wild land in Maine at 18,000 square miles, three-fourths of which is not incorporated. The unincorporated townships are in Aroostook, Franklin, Hancock, Penobscot, Piscataquis, Oxford, Somerset, and Washington counties, the value of which is fixed once every two years by the state assessors, and forms the valuation on which the state and county taxes are based. These unincorporated lands are subject to the same rate of state and county taxes as property located in cities and towns. In addition, the owners of wild land pay for the building and maintenance of all highways. In 1870 the total valuation of the unincorporated townships was fixed at $5,156,356, an average of 55 cents an acre. In 1880 the value was increased to $7,984,060, an average of 92 cents an acre. In 1890 the valuation was raised to $19,146,458, or by more than 100 per cent, the average value of each acre being $2.07. The state board of assessors was created in 1901, its first assessment made in 1902, since which time the unincorporated townships have been assessed $11,660,070, or 51 per cent more than in 1890. During the same period other property in the State has increased in value only 13 per cent."

This increase has continued till at present the wild lands are valued by the state assessors at $37,559,000. The State and counties derive from them an annual income of about $186,000.

The tax rate in the unincorporated places is made up of a uniform state rate of 3 mills, and a county rate varying from 1 to 5 mills and averaging 2 mills. The total tax rate is therefore in the neighborhood of 5 mills, or one-half of 1 per cent. This tax, combined with the evidently low valuation, means a very light burden of taxation. There has of late been considerable popular complaint against the relatively small taxes paid by the large lumber and paper companies and other wealthy owners of wild lands in the unincorporated parts of the State. A good deal of agitation in favor of higher taxes has resulted. At the last session of the legislature a commission was appointed to investigate the general subject of taxation, having this idea particularly in view. A plank in the Democratic platform in the State campaign last fall demanded higher taxation of wild lands. A most decided tendency to increase the valuation of wild lands is shown in the figures given above. It should be remembered, however, that there has been a great increase in actual values during recent years.

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[a] N. H. Tax Commission Report, 1908, pp. 175-199.

[b] American Lumberman, Sept. 22, 1906, p. 26.

In the incorporated towns of the State the average tax rate is about 21 mills,[a] or 2.1 per cent. This is slightly higher than in New Hampshire. In the absence of statistical data as to the relation between assessed valuation and true value, we can not determine definitely the burden of taxation. There seems, however, to be no widespread complaint of excessive taxation.

The data in the other New England States are not sufficient to warrant any positive conclusions as to the burden of taxation on timber lands. Occasional cases of excessive taxation are on record, as well as occasional cases where the owner admits his taxation is very light. There seems to be no evidence showing that timber lands are generally subjected to an excessive burden of taxation or that any widespread dissatisfaction exists. The following quotation is of interest in this connection:[b]

"In general, the assessment of white-pine lots is moderate, or even low, in comparison with the sale value. The rate of taxation varies exceedingly, but generally falls between $1.50 and $2 per hundred dollars valuation. The rate in some towns is as low as $1.20, but occasionally it reaches $3. Local taxation is controlled by the town, and the assessment and the rate depend upon the condition of the town's finances. The building of a new bridge or a schoolhouse often causes the tax rate to be raised considerably for a time. The valuation of the property is made by a local board of assessors, which frequently includes the valuation of a pine-wood lot in that of the whole farm of which it is a part. No exact rule exists with regard to the age at which a growing stand of pine shall begin to be taxed. Sometimes the assessors double or treble the valuation of a pine lot within a short period of years. Property is usually supposed to be revalued at stated intervals of eight or ten years, but this is not often regularly done.

"A high valuation or a heavy tax rate forces the owner to cut his pine lot at once. Towns where high taxes are levied on woodland are usually devoid of timber. Local assessors are beginning to learn, however, that a reasonable valuation and a moderate tax on pine lots for a considerable number of years mean a greater total income to the town than one heavy tax which compels the owner to cut his wood lot.

"Upon the whole, there is no great injustice practiced under the present method of taxation. Its greatest fault lies in the lack of a stable, regular system by which the valuation shall be fairly made and regularly increased according to the age and value of the stand, so that the owner may know whether he can afford to keep his stand and allow it to grow another ten years, when that period means a large proportionate increase in its yield."

The subject of forest taxation was investigated by a legislative committee in Massachusetts in 1905, but their report gives no data as to the actual burden of taxation on timber lands.[c]

IV. LETTERS FROM LOCAL ASSESSORS AND OTHER OFFICERS.

Some important material has been obtained from letters of local tax assessors, town and county officers, and others. These letters are in reply to a schedule of questions sent out by the Forest Service. Information has thus been received from 175 counties of Alabama, California, Iowa, Louisiana, Maryland, Michigan, Minnesota, New York, North Carolina, Pennsylvania, and

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[a] American Lumberman, Sept. 22, 1906, p. 26.

[b] Forest Service Bulletin, No. 63, p. 31.

[c] Report of Committee of 1905 to Consider the Laws Relative to the Taxation of Forest Lands. Massachusetts State Forest Service, Bulletin No. 3.

Washington. With reference to the particular subject of this chapter, these statements show for each county (1) the lowest, and (2) the highest, assessed valuations of timber lands; (3) the assessed valuation of what are considered representative tracts of timber land; (4) the estimated true value of representative tracts; (5) the total tax rate (state, county, town, etc.); (6) the fixed ratio of assessed valuation to true value, and (7) the ratio of the tax to the true value of the land. These figures, which are given in full in Table B following, speak for themselves, and discussion is hardly necessary. So far as they go, they show the wide range in the valuation of timber lands which we should naturally expect; they show that timber lands are valued for taxation far below their true value; and they show the well-nigh universal custom of assessing property considerably below its true value, generally at some fixed ratio.

The general conclusions to be drawn from these figures will appear more clearly from Table A below, where the results are summarized by States. For example, in 21 counties of Alabama representative tracts of timber land are assessed at from $1 to $20 per acre, the true values ranging from $1.25 to $25. The tax rate varies in the several counties from 1.15 per cent to 1.50 per cent. The ratio of assessed to true value ranges from 25 per cent to 75 per cent, though for nearly all the counties it is between 50 and 60 per cent, the average for all counties being 58 per cent. The ratio of tax to true value averages 0.79 per cent and is less than 1 per cent in every county. The table shows the corresponding facts for each of the other States. These figures seem to show heavy taxation in California, Michigan, and Washington, rather heavy in Iowa, Louisiana, Minnesota, and Pennsylvania, and a light burden in Alabama, Maryland, New York, and North Carolina.

TABLE A.

State.	Number of counties.	Assessed value of representative tracts.	True value of representative tracts.	Tax rate.	
				Range.	Average.
				Per cent.	*Per cent.*
Alabama	21	$1.00-$20.00	$1.25-$25.00	1.15-1.50	1.35
California	19	2.00-100.00	5.00-200.00	1.00-3.55	1.89
Iowa	20	1.00- 70.00	20.00-140.00	.35-5.00	2.71
Louisiana	24	1.00- 25.00	3.00- 75.00	1.00-3.50	2.03
Maryland	1	3.00- 20.00	20.00- 50.00	1.31	1.31
Michigan	18	4.00-100.00	5.00- 80.00	.86-4.13	2.18
Minnesota	18	2.00- 12.00	7.00-200.00	.84-4.20	2.55
New York	10	2.00- 50.00	3.00- 60.00	.20-1.90	.66
North Carolina	22	3.00- 20.00	4.00- 50.00	.60-1.30	.90
Pennsylvania	11	1.00- 50.00	1.00- 75.00	.40-3.20	1.45
Washington	11	1.02- 17.92	.75-100.00	1.38-3.50	2.03

State.	Number of counties.	Ratio of assessed to true value.		Ratio of tax to true value.			
		Range.	Average.	Range.	Average.	Number of counties having ratio of—	
						1 per cent or over.	Less than 1 per cent.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*		
Alabama	21	25- 75	58	0.35-0.98	0.79	0	20
California	19	20-100	63	.37-1.64	1.17	15	4
Iowa	20	20-100	45	.28-2.55	1.06	8	10
Louisiana	24	25- 75	47	.33-2.10	.95	8	14
Maryland	1						
Michigan	18	50-100	71	.43-3.00	1.46	6	4
Minnesota	18	20- 60	38	.28-2.40	.96	4	8
New York	10	50- 75	66	.11-1.46	.63	1	5
North Carolina	22	25-100	58	.17-1.30	.51	1	15
Pennsylvania	11	33-100	71	.27-1.90	.89	3	6
Washington	11	25- 60	47	.34-2.06	1.30	5	1

TABLE B.—*Showing assessed valuation and true value of timber lands; also tax rate, fixed ratio of assessed to true value, and ratio of tax to true value, in certain States and counties, 1908.*

State and county.	Assessed valuation per acre. 1. Lowest.	2. Highest.	3. Representative tracts.	4. True value per acre, representative tracts.	5. Total tax rate.	6. Fixed ratio of assessed to true value.	7. Ratio of tax to true value.
ALABAMA.					*Per cent.*	*Per cent.*	*Per cent.*
Autauga	$5.00	$15.00	$5.00-$20.00	.....	1.35	60	0.81
Bibb	10.00	20.00	.....	.....	1.3	50	.65
Bullock	.....	.....	.....	.....	1.175	60	.71
Clarke	3.00-5.00	10.00	3.00- 10.00	$20.00	1.3	50-75	.65-.98
Clay	2.00	10.00	3.00	5.00	1.5	60	.90
Conecuh	5.00	13.00	10.00- 12.50	20.00- 25.00	1.5	50-60	.75-.90
Dale	5.00	15.00	.....	.....	1.4	60	.84
Escambia	2.50	8.50	4.00	6.00	1.4	60	.84
Greene	1.00	2.50	1.50	2.00- 3.00	1.25	75	.94
Henry	3.00	5.00	3.00	25.00	1.4	25	.35
Jefferson	3.00	10.00	5.00	8.00	1.3	60	.78
Lamar	1.00	2.50	2.00	3.00	1.4	50	.70
Lee	.....	.....	.....	.....	1.3	60	.78
Macon	4.05	4.05	4.05	.....	1.15	60	.69
Madison	1.00	15.00	.....	.....	1.45	60	.87
Marshall	.50	3.00	3.00	1.50	1.5	60	[b].90
Mobile	1.50	2.50	2.00	10.00	1.2	.....	.....
Monroe	3.00-5.00	10.00-15.00	5.00- 10.00	.....	1.5	(a)	(b)
St. Clair	1.00	3.00	1.00	1.25	1.35	60	.81
Sumter	4.00	6.00	6.00	10.00	1.35	60	.81
Talladega	3.00	8.00	6.00	10.00	1.25	67	.84
CALIFORNIA.							
Alpine	2.00	1.25	2.50	5.00	2.25	50	1.13
Amador	3.00	15.00	5.00	10.00	2.0	50-60	1-1.20
Colusa	2.00	50.00	2.00- 50.00	5.00-100.00	1.6	50	.80
Glenn	7.00	12.00	10.00	18.00	1.86	60	1.12
Humboldt	5.00	80.00	5.00-100.00	8.00-200.00	2.0	60	1.20
Kings	5.00	50.00	25.00	40.00	1.65	67	1.11
Lassen	3.50	12.50	3.50- 12.50	3.50- 12.50	1.8	60	1.08
Modoc	3.00	8.00	6.00	9.00	1.98	67	1.33
Napa	(c)	(c)	(c)	(c)	1.62	67	1.09
Orange	(d)	(d)	(d)	(d)	1.7	40	.68
Placer	.....	.....	5.00	10.00	2.0	67	1.34
Riverside	5.00	.....	5.00- 10.00	20.00- 50.00	1.85 3.55	20-35	.37 .71 .65-1.24
Siskiyou	6.00	7.00	6.00- 7.00	10.00- 20.00	1.62	60	.97
San Benito	.....	.....	.....	.....	2.0	60	1.20
San Luis Obispo	.....	15.00	.....	.....	1.9	60	1.14
Santa Clara	(e)	(e)	(e)	(e)	1.64	100	1.64
Shasta	5.00	8.00	8.00	10.00- 50.00	2.1	75	1.58
Tehama	2.50	8.00	2.50- 8.00	.....	1.6	100	1.60
Tuolumne	5.00	100.00	10.00	.....	2.0	67	1.34
IOWA.							
Adair	4.00	6.00	4.00	25.00	3.0	25-33	.75- .90
Appanoose	15.00	20.00	16.00	20.00	3.35	80	.28
Cedar	4.00	40.00	4.00-40.00	20.00-100.00	2.5	60	1.50
Decatur	5.00	40.00	5.00-10.00	20.00- 40.00	3.51	20	.70
Delaware	1.00	40.00	.....	.....	3.5	25	.88
Grundy	44.00	56.00	53.00	100.00	1.6	50	.80
Hamilton	.....	.....	.....	.....	2.5 3.4	25	.63 .85
Hardin	.....	.....	40.00	60.00	.....	.....	.....
Henry	15.00	20.00	40.00	140.00	2.99	33	.99
Iowa	.....	.....	10.00-30.00	30.00-75.00	3.0	33-50	.99-1.50
Jasper	4.00	80.00	60.00-70.00	95.00	2.5	25	.63
Mahaska	.....	.....	.....	.....	.....	67	.....
Mills	20.00	40.00	20.00	45.00	3.0	67	2.01
Monona	.....	.....	.....	.....	3.0	20-85	.60-2.55
Montgomery	16.00	36.00	.....	.....	3.0	50	1.50
Page	24.00	37.00	41.00	50.00	2.7	25	.68
Pocahontas [f]	(f)	(f)	38.57	50.00	2.95	50	1.48
Shelby	1.00	1.00	1.00	.....	1.84	25	.46
Sioux	.....	.....	.....	.....	1.45	100	1.45
Webster	20.00	39.00	37.50	50.00	5.	25	1.25

[a] More than 60 per cent.
[b] More than 90 per cent.
[c] No timber land.
[d] No timber land assessed separately.
[e] Mostly cut over.
[f] Little timber.

TABLE B.—*Showing assessed valuation and true value of timber lands; also tax rate, fixed ratio of assessed to true value, and ratio of tax to true value, in certain States and counties, 1908*—Continued.

State and county.	Assessed valuation per acre.			4. True value per acre, representative tracts.	5. Total tax rate.	6. Fixed ratio of assessed to true value.	7. Ratio of tax to true value.
	1. Lowest.	2. Highest.	3. Representative tracts.				
LOUISIANA.					*Per cent.*	*Per cent.*	*Per cent.*
Bossier	$5.00	$5.00	$5.00	$10.00	1.3 2.55	50	0.65 1.28
Calcasieu	5.00	17.00	12.00	36.00	2.05	33	.68
Caldwell	2.50	10.00	2.50-10.00	4.00-15.00	2.0 2.5	50-75	1.00 1.25 1.50 1.88
Cameron	....	....	....	....	1.5	50	.75
Catahoula	2.00	17.00	2.00-17.00	4.00-40.00	1.5 2.5	50	.75 1.25
Claiborne	2.00	3.00	2.40	5.00	1.8	50	.90
East Feliciana	....	....	....	....	1.35	50	.68
Franklin	2.00	10.00	4.00	8.00-12.00	1.6 1.8	50	.80 .90
Grant	5.00	17.00	5.00-17.00	15.00-50.00	1.0	33⅓-50	.33⅓-.50
Iberville	10.00	20.00	10.00	25.00	2.6	40	1.04
Jefferson	10.00	50.00	25.00	50.00	2.7	50-67	1.35-1.81
Lafayette	5.00	8.70	8.70	25.00	2.0	....	....
Lincoln	2.35	2.35	2.35	....	2.0 2.5	33	.66 .83
Livingston	5.00	20.00	5.00-20.00	25.00-30.00	1.3	60	.78
Morehouse	5.00	10.00-12.00	2.00-10.00	40.00-60.00	2.3	40-60	.92-1.38
Nachitoches	5.00	17.00	5.00-17.00	8.00-30.00	2.55	50	1.28
Ouachita	1.25	5.00	5.00	10.00	1.8	50	.90
St. Bernard	5.00	5.00	1.00- 5.00	3.00-10.00	3.5	60	2.10
St. Martin	5.00	20.00	12.33⅓	50.00	2.5	33⅓	.83
Tensas	2.00	15.00	2.00-10.00	5.00-15.00	2.5	50	1.25
Terrebonne	5.00	20.00	5.00-20.00	10.00-40.00	2.55	....	....
Vernon	2.00	17.00	5.00-17.00	10.00-75.00	1.5 2.5	25-33⅓	.38 .63 .50 .83
Washington	5.00	17.00	10.00	20.00	1.5	25-50	.38-.75
West Feliciana	1.50	10.00	....	....	1.0	33⅓	.33
MARYLAND.							
Caroline	3.00	20.00	3.00-20.00	20.00-50.00	1.31	....	....
MICHIGAN.							
Alger	1.50	10.00	6.00	10.00	3.44	50	1.72
Allegan	1.00	5.00	40.00-60.00	40.00-80.00	1.0 2.0	75-80	.75 .80 1.50 1.60
Antrim	20.00	50.00	35.00	35.00	3.0	100	3.00
Bany	....	....	....	....	3.0	90	2.70
Benzie	12.00	25.00	20.00	....	....	100	....
Gratiot	....	....	....	....	....	67	....
Hillsdale	15.00	20.00	....	....	.9 1.25	50-75	.45 .63 .68 .94
Huron	....	....	....	....	....	67	....
Kent	50.00	100.00	75.00-100.00	75.00	1.0	100	1.00
Mecosta	....	....	....	....	....	67	....
Monroe	....	....	....	....	1.25	75	.94
Ontonagon	4.00	12.00	4.00-12.00	5.00-20.00	4.125	50	2.06
Oscoda	....	20.00	20.00	30.00	....	50	....
Ottawa	10.00	50.00	10.00	30.00	.86	50	.43
Presque Isle	5.00	50.00	18.00	18.00	2.75	50	....
Washtenaw	....	....	35.00	35.00-40.00	....	80-90	....
MINNESOTA.							
Brown	5.00-12.00	12.00	12.00	25.00-40.00		20-50	
Carlton	3.00	6.00	3.77	7.54	....	50	....
Chisago	10.00	40.00	10.00	30.00	2.0	33⅓	.67
Cottonwood	....	....	....	....	2.0	....	....
Crow Wing	5.00	6.00	5.00	7.00	1.6 4.0	60	.96 2.40

TABLE B.—*Showing assessed valuation and true value of timber lands; also tax rate, fixed ratio of assessed to true value, and ratio of tax to true value, in certain States and counties, 1908*—Continued.

State and county.	Assessed valuation per acre.			4. True value per acre, representative tracts.	5. Total tax rate.	6. Fixed ratio of assessed to true value.	7. Ratio of tax to true value.
	1. Lowest.	2. Highest.	3. Representative tracts.				
MINNESOTA—cont'd.					*Per cent.*	*Per cent.*	*Per cent.*
Faribault	....	....	....	....	....	33⅓	....
Kittson	....	....	....	....	2.96	50	1.48
Lac qui Parle	....	....	$12.00	$35.00	....	33⅓	....
Lincoln	....	....	....	....	.84	33⅓	.28
Polk	(a)	(a)	6.00	100.00-200.00	4.2	25	1.05
Renville	....	....	....	....	2.1	40	.84
Rock	....	....	....	....	2.28	33⅓	.70
Roseau	....	....	....	....	4.0	33⅓	1.33
Stevens	....	....	....	....	2.8	33⅓	.93
Washington	....	....	....	....	....	(b)	....
Watonwan	....	....	....	....	2.325	33⅓	.78
Yellow Medicine	....	....	....	....	2.066	33⅓	.69
NEW YORK.							
Cattaraugus	$5.00	$8.00	5.00	20.00-50.00	.225	50	.11
Cayuga	....	....	....	5.00-15.00	.5 1.5	75	.38 1.13
Chautauqua	....	....	30.00	60.00	.25	50	1.13
Chemung	....	....	6.00	10.00	.5	67	.34
Chenango	....	....	....	....	.586 1.94	75	.44 1.46
Lewis	2.00	10.00	2.00-10.00	3.00-15.00	....		....
Orleans	.10	50.00	5.00-10.00	10.00-20.00	.7	67	.47
Otsego	....	....	....	....	....	70	....
Putnam	50.00	5.00	25.00-50.00	5.00	....	67	....
Yates	....	....	....	....	....	75	....
NORTH CAROLINA.							
Ashe	1.00	5.00	5.00	15.00	1.00	33⅓	.33
Buncombe	2.50	15.00	4.00	4.00	1.3	100	1.30
Camden	1.50	3.00	3.00	6.00	1.16	50	.58
Caswell	....	....	6.00	15.00-20.00	1.00	33⅓	.33
Cherokee	4.00	12.00	4.00	6.00	.6	80	.48
Craven	4.00	8.00	8.00	25.00	.95	50-67	.48-.64
Forsyth	10.00	25.00	5.00-10.00	10.00-25.00	1.0	50-67	.50-.67
Granville	6.00	15.00	6.00	10.00	.8	60	.48
Greene	10.00	30 00	10 00	20 00	....	50	....
Harnett	3.00	5.00	5.00	12.00-15.00	.8	33⅓-50	.27-.40
Hyde	30.00	60.00	20.00	50.00	.67	67	.45
Iredell	8.00	15.00	8.00-10.00	30.00-40.00	.67	25 95	.17 .64
Lenoir	1.00	5.00	....	....	.97	50-67	.49-.65
Macon	2.00	5.00	3.00	5.00	1.005	50	.50
Madison	3.00-6.00	20.00	5.00-15.00	10.00-30.00	1.037	50	.52
Montgomery	3.00	20.00	5.00	7.00	.87	....	....
Randolph	3.00	20.00	5.00	15.00	.75	....	....
Scotland	....	....	....	10.00	1.077	....	....
Stokes	1.00	12.00	5.00	10.00	....	50	....
Swain	5.00	....	5.00	12.00	.847	....	....
Washington	5.00	10.00	6.00	10.00	.667	33	.22
Yadkin	7.00	15.00	8.00	15.00	.757	67	.51
PENNSYLVANIA.							
Adams	18.00	65.00	30.00	50.00	.4	67	.27
Blair	1.00	10.00	1.00-10.00	1.00-10.00	1.4	100	1.40
Carbon	30.00	125.00	10.00	30.00	1.0	33⅓	.33
Cumberland	5.00	75.00	1.00-50.00	1.00-75.00	1.0	80	.80
Jefferson	20.00	30.00	20.00-30.00	35.00-50.00	1.5 3.0	60	.90 1.80
Mercer	20.00	25.00	13.50	20.00	.8	75	.60
Mifflin	.50	2.00	1.00	2.00	1.57	50-67	.79-1.05
Pike	1.25	1.50	1.50	....	3.2	....	....
Tioga	20.00	50.00	....	....	.6	67	.40
Venango	8.00	25.00	12.00-15.00	30.00-40.00	1.8	....	....
Wayne	10.00	....	25.00	50.00	1.9	100	1.90

[a] Uniform assessment of $6 per acre.

[b] Less than 50 per cent.

TABLE B.—*Showing assessed valuation and true value of timber lands; also tax rate, fixed ratio of assessed to true value, and ratio of tax to true value, in certain States and counties, 1908*—Continued.

State and county.	Assessed valuation per acre.			4. True value per acre, representative tracts.	5. Total tax rate.	6. Fixed ratio of assessed to true value.	7. Ratio of tax to true value.
	1. Lowest.	2. Highest.	3. Representative tracts.				
WASHINGTON.							
					Per cent.	*Per cent.*	*Per cent.*
Adams						60	
Chehalis	$5.00	$25.00	$12.50	$50.00	1.375	25	0.34
Island	7.00	40.00	7.00-40.00	20.00-100.00	3.0	40	1.20
Klickitat	a b.50	a c.50	6.00	10.00	2.2	60	1.32
Lewis	5.00	118.00	17.92	30.00	1.8 2.8	60	1.08 1.68
Skagit	a.20	a 1.00				60	
Snohomish	a.25				3.44	60	2.06
Stevens	1.25		3.00	10.00	3.5	40	1.40
Wahkiakum	d.25	d.80				25	
Yakima	.75	10.00	1.02	.75-2.50		60	
Pacific						30	

[a] Valuation of stumpage per m. [b] Plus land at $1.25. [c] Plus land at $2.50. [d] Per m.

V. MISCELLANEOUS EVIDENCE.

Some valuable evidence regarding the taxation of timber lands in Illinois has been prepared by a member of the Forest Service. Nine counties were studied, from which we obtain the following information: The average tax rates of the different counties range from 4 to 6 per cent, the average for all nine counties being 4.75 per cent. The practice of assessors in these counties is to value property very low. The assessed valuations run from one-fifth to one-eighth of the true value, or even less. For example, in one county improved lands were assessed on the average at $12 per acre and unimproved lands at $1.70. The market value of land in this county is estimated at from $40 to $60 per acre for improved lands, and from $5 to $15 for unimproved lands. In another county where improved lands were assessed at an average of $5.48 per acre, the true value was estimated at from $25 to $35. In another county the average assessed value of improved lands was $7.15, while the true value was estimated at about $35. The average assessed valuation of improved and unimproved land and the average tax rate for each county are shown in the following table:

Illinois, nine counties.

County.	Average assessed valuation of land.		Average tax-rate percentage.
	Improved.	Unimproved.	
Alexander	$12.01	$1.71	5
Clinton	5.48	1.49	4
Fayette	7.15	3.49	4
Gallatin	7.10	1.72	5.75
Jackson	31.15	7.46	4
Johnson	5.50	1.55	4
Pope	6.34	2.64	6
Saline	5.41	1.20	6
Union	6.24	1.96	4

Combining these tax rates with the ratios of assessed valuation to true value, ranging from one-fifth to one-eighth, it would appear that lands are taxed on the whole somewhat less than 1 per cent of their true value, the general run being perhaps two-thirds of 1 per cent up to 1 per cent. These, of course, are only averages for the several counties. Extreme cases must undoubtedly be present, involving exceptionally high and exceptionally low taxation. It seems reasonable to conclude, however, that the majority of the lands in these counties are certainly not taxed more than 1 per cent of the true value.

The following quotation is of interest as showing the condition in Kentucky:[a] "The present valuation and rate of taxation on forest property seems fair and just and should remain as it is, as far as possible. When a rise in the valuation of other than forest property becomes necessary because of the greater development of the resources of the region, the valuation of forest property should be increased with great caution in order that the forest lands may be held to advantage for the production of future timber crops.

"In view of these facts, it is recommended that taxation of forest lands in this region be kept as nearly on its present basis as possible. If a readjustment of valuation should become necessary, care should be taken not to impose taxes that will prevent the profitable holding of forest lands by the private citizen for the production of timber."

A great deal of discussion of the taxation of timber lands has recently appeared in the forestry journals, the lumber trade journals, the publications of the United States Forest Service and of the several state foresters, and elsewhere. From these writings a few interesting examples of timber-land taxation may be culled. These sources are undoubtedly reliable, but naturally the cases given are mostly those of excessive taxation. A few cases may be worth while as showing, not the prevailing situation, but rather the extremes of excessive taxation found here and there. For example, "the forest commissioner of Pennsylvania reports that on one of the few pieces of virgin forest still standing in the State, containing a little less than 1,000 acres, the annual tax is $2.83 per acre. If the whole tract averages 20,000 feet per acre of white pine worth $10 a thousand on the stump—both estimates are high—the tax is 1.4 per cent of the value. The same authority * * * states that denuded lands are commonly assessed from 50 cents to $1.25 per acre, and that the usual levies amount to 25 to 30 mills. This means a yearly tax of 1¼ to 3¾ cents per acre. * * * The state forest reserve commission has bought at tax sales over 23,000 acres of such lands for the accrued taxes and costs. * * * The commissioner mentions one case where several parcels containing over 7,000 acres were bought in for a fraction over 8 cents per acre."[b]

It is stated that in Wisconsin the taxes on forest lands have been for years from 3 cents to 40 cents an acre without reference to changes in its condition or value, although more than one-third of the area of the State consists of cut-over lands too poor to be farmed and which may be bought for 25 cents to 50 cents per acre.[c]

"In North Carolina conditions are not much different. The common levy is 1 per cent on a 60 per cent valuation, or 6 mills on the estimated value. Where this value is justly assessed there can be no reasonable complaint, but there is much guessing, and in one county it is reported that land partly lumbered, or cut over as the forester advises, is taxed 25 per cent higher than virgin forest, on the ground that it is improved land. In other words, a penalty is imposed on conservative lumbering!"[d]

According to one of the Forest Service bulletins, cut-over lands in western Washington, which are valuable for nothing except the production of timber, are assessed at from $1 to $5 per acre, with a tax rate of from 15 to 30 mills on the dollar. These lands are estimated by the same authority as actually worth not more than $1 per acre. Large tracts of this land have been sold for 40 cents an acre.[e]

An interesting example of increased assessment comes from Oregon. One owner paid taxes amounting to $496.69 in 1907 and this year was called upon to pay $1,855.32, an increase of 274 per cent. Another tract was taxed $528.50 in 1907 and $1,804.54 in 1908. In another instance a timber claim which the owner was willing to sell for $2,400 was assessed for $4,700.[f]

Besides a mass of other similar evidence from the sources quoted above, the writer is in possession of a great deal of testimony from letters which he is not at present at liberty to make public. This testimony is in general accord with the evidence presented, and has been drawn upon in forming the conclusions expressed in the text. In New Jersey, for example, it is stated that timber lands are not compelled to bear a heavy burden of taxation at the present time, although here and there individual cases of excessive taxes are to be found. In general, timber lands are assessed far below their true value. In south New Jersey it is said that land bearing young pine is commonly taxed on a value not exceeding $1 per acre and that hard-wood forests in the northern part of the State, when newly cut over, are often assessed no higher than this. Similar testimony is at hand from Georgia, to the effect that the very low assessment of forest lands has thus far prevented excessive taxation on any large scale.

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[a] Hand Book of the Kentucky State Department of Agriculture, 1906–7, p. 115.

[b] Gaskill, Proceedings of the Society of American Foresters, April, 1906, p. 119.

[c] Gaskill, Proc. Soc. Am. Foresters, April 1906, pp. 118–119. Fernow, Economics of Forestry, p. 252.

[d] Gaskill, Proc. Soc. Am. Foresters, April, 1906, p. 120.

[e] Forest Service Bulletin, No. 33, pp. 36–37.

[f] Langille, The Timberman, April, 1908, p. 42.

CHAPTER IV.

THE EFFECTS OF TAXATION ON THE FORESTS OF THE UNITED STATES.

Having shown, in a general way, what the actual burden of taxation on timber lands is at present, we must next inquire what effects taxation has had upon the forests of the country. It is commonly charged that taxation is responsible, (1) for a great deal of premature cutting of timber which would otherwise be left to grow to larger size; (2) for wasteful and destructive methods of cutting, commonly called "skinning;" (3) for the failure to hold lands once cut over for a second crop; and (4) for the general absence of the practice of forestry in America. It is important to know how far these charges are sustained by facts.

To a considerable extent the answer to this question may be inferred from the foregoing conclusions as to the burden of the general property tax on forests. There can be no doubt that in many of the cases where taxation has been excessive it has hastened the cutting of timber and led to wasteful skinning of the land, often destroying the chance of a valuable second growth, and sometimes leading to the abandonment of the land for delinquent taxes. On the other hand, in all those cases where the tax burden has been very small, taxation can obviously have had little influence on the management of the property.

The evidence on this question is from much the same sources as the evidence upon the burden of taxation discussed in Chapter III. This evidence, so far as it goes, shows that in some States, where taxation of timber lands and waste lands has been excessive, the taxation has had some influence in causing premature and wasteful cutting and in preventing the holding of cut-over lands for a second crop. Such evidence comes mainly from the States of Michigan, Wisconsin, Minnesota, Washington, and California. These are the States where we have seen some tendency toward excessive taxation of timber lands. The effects of taxation are more noticeable in preventing the reforesting of cut-over lands than in altering the management of mature or growing timber. These five are among the most important lumber-producing States of the country. They furnished one-fourth of the total cut in 1907. In them there is some evidence showing that considerable cut-over land has been abandoned because of the heavy taxation. This matter of abandoned lands is discussed more fully below.

On the other hand, there is evidence from a great many States tending to show that taxation has had no appreciable effect on the forests. These are States where the burden of taxation is so very light that it is seldom considered by timber owners and lumbermen.

In the general run of ordinary cases, as has been shown, the present burden of taxation can not be considered excessive. And in the general run of cases also there is little evidence to show that forests have been affected seriously by taxation. Indeed there is much positive evidence to the contrary. Among other sources, we have letters from nearly five hundred of the leading lumbermen of all parts of the country, written in reply to a schedule of inquiry sent out by the Forest Service. In answer to a question as to the influence of taxation on their lumbering operations, only 125 admit that it has had any appreciable effect. This includes a number of doubtful ones. The number that clearly testify to some undoubted influence on the part of taxation probably does not exceed 100. Of the replies, 234 state absolutely that taxation has had no influence, or very little. This testimony is discussed and the replies tabulated by States in the appendix to this chapter, from which it will be seen that the chief complaint of serious results of taxation comes from a small number of States, to some of which attention has already been called.[a] As said above, however, these States include some of the most important timber-producing States in the country.

It appears that in the general run of ordinary cases and in most parts of the country, at any rate outside of the five States named above, taxation has not had any great influence in causing the cutting of timber, and not very much influence in preventing reforesting. That the American forests have been cut off at a tremendous rate of late years, that the methods of cutting have often been wasteful and destructive of future growth, and that there is little tendency on the part of lumbermen to reforest cut-over lands are facts which need no demonstration. But that taxation has generally been an important influence in bringing about these results is an inference apparently not warranted by the facts. This is a phase of the problem which has been greatly exaggerated. The explanation probably lies in the fact that most of the discussion thus far has been on the part of those who were complaining against some particular cases of evil results from excessive taxation. That such cases undoubtedly exist in considerable number has already been shown. That they do not represent the prevailing situation has also been shown. The recent heavy and wasteful cutting of our forests has been due to various economic influences, among which taxation has played a comparatively small rôle.

A good deal of cut-over land has been abandoned for taxes in certain parts of the country, particularly in the States in the region of the Great Lakes and on the Pacific coast. California probably has about a million acres of such delinquent-tax lands. Michigan also has about a million acres. Wisconsin has a large area. In some cases this has been due, in part at least, to excessive taxation. For example, in western Washington cut-over lands are assessed at from $1 to $5 per acre, although according to the estimate of a Forest Service expert the land is not worth more than $1 per acre, and large tracts have actually been sold for 40 cents an acre.[b] But while this state of affairs exists in some States, and is in some cases due to excessive taxation, still throughout the country as a whole there is very little land abandoned for taxes, and in the great majority of the States the matter of abandoned lands is negligible.

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[a] See Appendix to Chapter IV, p. 608.

[b] Forest Service Bulletin No. 33, pp. 36, 37, 45.

As evidence on this point, it is significant that out of nearly five hundred letters from lumbermen all over the country only eight stated that taxation had led them to abandon their lands.[a] Further evidence on this subject comes from letters received from local tax assessors and others in 177 counties of Alabama, California, Iowa, Louisiana, Maryland, Michigan, Minnesota, New York, North Carolina, Pennsylvania, and Washington. Out of these 177 counties only 25 report any appreciable amount of abandoned lands; and, so far as these replies go, they seem to show that in the great majority of counties practically no land is being sold or abandoned for taxes, and that in only a few counties is the question of delinquent tax lands a matter of any importance.[b]

Forestry is very little practiced in America to-day, but that this state of affairs has been due in any great measure to taxation is denied by the evidence. The lumbermen, as a rule, are not thinking much about forestry. There are other factors in the forestry problem of far greater weight than taxation, and the general practice of forestry will not be brought about by amendments to the tax laws. This conclusion also is supported by the great majority of the letters received from lumbermen all over the country. The majority either ignore the question altogether or state that a change in taxation would make no difference in the management of their lands. And of the others, very many admit only a problematical effect, or an effect in some cases. In answer to the specific question, whether reduced taxes would lead to planting or holding cut-over lands for second growth, the number of affirmative replies is still smaller.[c]

We conclude, then, that while in some cases, and in certain parts of the country, forests have been excessively taxed with more or less serious results, as a general rule taxation has not, up to the present time, been responsible for any widespread disastrous results on the forests of the country.

APPENDIX.

SOME EVIDENCE REGARDING THE EFFECTS OF TAXATION ON THE FORESTS OF THE UNITED STATES.

1. LETTERS FROM LUMBERMEN.

The following questions, among others, were sent to representative lumbermen all over the country by the Forest Service in the summer of 1908:

1. In what way, if any, have your lumbering operations been influenced by the rate of taxation applied to your holdings?

2. Would a reduced tax lead you to adopt different methods so as to preserve young growth or to leave seed trees in order to provide for a future crop, and for the protection of cut-over land from fire?

a. Would it lead you to plant such of your holdings as have been cut over when planting is necessary?

b. Would it influence you not to abandon cut-over lands? If so, what would the ratio between the present tax and the reduced tax have to be?

About 500 answers were received which give some valuable testimony as to the effects of taxation on the forests of the country. Incidentally they throw some light on the actual burden of taxation on timber lands. In some cases the replies are not very clear, and it has requiued the exercise of some judgment to tabulate them. The doubtful cases, however, are not numerous enough to affect the conclusions to be drawn from the answers.

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[a] See above; also Appendix to Chapter IV, p. 609.

[b] The full replies to this question are given by States and discussed, together with some other evidence on the subject of abandoned tax lands, in the Appendix to Chapter IV, p. 611.

[c] The evidence is presented and discussed in the Appendix to Chapter IV, pp. 611.

The answers to the first question may be classified as follows:

Answers to question 1.

1. Number of letters received	484
2. No information on this question	117
3. No influence, or very little	234
4. Probable future influence	8
5. Some influence	125
a. Character not specified	1
b. Hastens cutting	117
c. Leads to abandoning land	8

The cases in which taxation is said to have exercised some influence include a number of rather vague replies. Probably the number that clearly testify to some real influence would not be over 100. These replies are significant as showing how little influence taxation has really had upon the management of forest properties.

The replies give additional information of interest when they are classified by States, as is done in the following table, though the number of cases in many individual States is too small to allow the drawing of any positive conclusions:

Answers to question 1, by States.

State.	1. Number of letters received.	2. No information.	3. No influence, or very little.	4. Probable future influence.	5. Some influence.			
					Total.	*a.* Character not specified.	*b.* Hastens cutting.	*c.* Leads to abandoning land.
Alabama	6	2	3	....	1	....	1	....
Arkansas	21	6	7	1	7	....	7	....
California	10	1	9	....	0	....	....	....
Connecticut	13	5	7	....	1	....	1	....
Delaware	1	0	1	....	0	....	....	....
Florida	11	2	5	....	4	....	4	....
Georgia	10	5	5	....	0	....	....	....
Idaho	6	0	4	1	1	....	1	....
Indiana	1	1	0	....	0	....	....	....
Kentucky	8	3	4	....	1	....	1	....
Louisiana	33	4	14	....	15	....	15	....
Maine	9	6	2	....	1	....	1	....
Maryland	4	1	2	....	1	....	....	1
Massachusett's	30	6	17	....	7	....	5	2
Michigan	17	1	9	....	7	....	7	....
Minnesota	8	2	1	....	5	....	5	....
Mississippi	18	3	11	1	3	....	3	....
Missouri	6	1	3	....	2	....	2	....
Montana	10	1	6	....	3	....	3	....
New Hampshire	9	3	3	....	3	....	3	....
New Jersey	2	2	0	....	0	....	....	....
New York	34	12	15	....	7	....	5	3
North Carolina	17	5	10	....	2	....	2	....
Ohio	1	0	1	....	0	....	....	....
Oklahoma	2	1	1	....	0	....	....	....
Oregon	34	5	23	2	4	1	3	....
Pennsylvania	8	1	2	....	5	....	5	....
Rhode Island	1	0	1	....	0	....	....	....
South Carolina	10	2	8	....	0	....	....	....
Tennessee	9	3	6	....	0	....	....	....
Texas	19	3	10	....	6	....	6	....
Vermont	7	2	2	....	3	....	3	....
Virginia	12	4	7	....	1	1	....	....
Washington	55	16	21	3	15	....	13	2
West Virginia	16	4	8	....	4	....	4	....
Wisconsin	34	6	9	....	19	....	19	....
All others [a]	5	1	4	....	0	....	....	....
Total [b]	497	120	242	8	128	2	119	8

[a] Cases where the State was not indicated.

[b] The totals here exceed those in the summarized table above, for the reason that replies from companies operating in more than one State have been counted under each State.

The replies to questions 2, 2*a*, and 2*b* show the following results:

Answers to question 2.

1. Number of letters received	484
2. No information on this question	100
3. No, or doubtful	166
4. Yes, or probably, or in some cases	218

Answers to question 2a.

1. Number of letters received	484
2. No information on this question	173
3. No, or doubtful	182
4. Yes, or possibly, or would consider it	129

Answers to question 2b.

1. Number of letters received	484
2. No information on this question	184
3. No	123
4. Yes	177

Here also, as in tabulating the answers to the first question, a good many rather vague statements have been counted as affirmative replies. The number of clear and positive affirmatives would be considerably below the figures given above.

II. LAND ABANDONED ON ACCOUNT OF TAXES.

Some interesting evidence on the subject of delinquent-tax lands has been obtained from letters of local assessors, town and county officers, and others, received in reply to a schedule of questions sent out by the Forest Service. One of these questions was, "To what extent has cut-over land in your locality reverted to the county or State or been sold because of nonpayment of taxes?" Answers to the general schedule were received from 175 counties of Alabama, California, Iowa, Louisiana, Maryland, Michigan, Minnesota, New York, North Carolina, Pennsylvania, and Washington. In answer to the question about delinquent-tax lands, 73 counties report "none;" 37, "very little;" 2, "none lately;" 38 give no answer at all; and 25 report some abandoned lands together with some information as to their extent. The information contained in these last 25 replies is as follows:

In Alabama, one county reports one-fourth of 1 per cent, another 1 per cent, and the third, "some." In California, one county reports one-twentieth, and one, 23,638 acres. Four counties in Louisiana report, respectively, "some, but soon redeemed," 15 per cent, 360, and one-tenth. Six counties in Michigan answer, respectively, 5 per cent, less than 1 per cent, 1,009, 10 per cent, 10 per cent, and 300. One county in Minnesota reports 300 acres. Two counties in New York report, respectively, 10 per cent, and 6 per cent. In North Carolina, one county reports 10 per cent and another 5 per cent. In Pennsylvania 5 counties report, respectively, "some," "great extent," "300 acres every two years," 1,000 acres, and "nearly all." The exact meaning of these replies is not always very clear.

These replies, so far as they go, seem to show that in the great majority of counties practically no land is being sold or abandoned on account of taxes, and that in only a few of the counties is the question of delinquent-tax lands a matter of any importance. The returns, summarized by States, are given in the following table:

Lands abandoned on account of taxes.

State.	Number of counties.	None.	Very little.	None lately.	No answer.	Some; extent specified.
Alabama	21	9	6	1	2	3
California	19	3	6	1	7	2
Iowa	20	15	1		4	
Louisiana	24	14	3		3	4
Maryland	1	1				
Michigan	18	7	2		3	6
Minnesota	18	3	3		11	1
New York	10	3	4		1	2
North Carolina	22	11	7		2	2
Pennsylvania	11	3	2		1	5
Washington	11	4	3		4	
Total	175	73	37	2	38	25

The following statement, taken from Forest Service Bulletin No. 33, page 37, gives some additional evidence. The reports were furnished by the assessors of some of the timbered counties of the State of Washington, and state the amount of cut-over land which has been abandoned:

Abandoned lands in Washington.—Chehalis County, 71 per cent; Clallam County, none nominally abandoned, much delinquent; Clarke County, none; Jefferson County, 20 per cent; King County, none; Pacific County, none at present, indications that large amount will be abandoned; Pierce County, information wanting; Skagit County, very little; Whatcom County, 20 per cent.

CHAPTER V.

THE REAL ECONOMIC PROBLEM OF FOREST TAXATION.

It does not follow from the conclusion reached in the last chapter that the problem of forest taxation is of no importance or of academic interest only. The problem is, in fact, of the utmost importance, and is moreover decidedly practical. But its practical bearing is on the future of our forests rather than on their past. The methods of handling the forests of the United States which have prevailed in the past can not continue much longer. This statement is supported by such an overwhelming mass of testimony on the part of the forestry experts that we may accept it without further discussion. On the same authority we accept the proposition that the preservation of our forests is a matter of urgent importance, and that disastrous consequences are bound to follow their destruction. The practice of forestry, then, must come some time, and its speedy coming is a thing greatly to be desired; and whenever we are ready to seriously undertake it, we will find our present methods of taxation a heavy handicap. It is then that taxation will appear as a vitally important element in the situation.

It can be shown theoretically that the general property tax, strictly enforced in accordance with the letter of the law, must inevitably lead to excessive taxation in all cases of invested wealth which is appreciating in value. Suppose a man invests $10,000 in a perpetual annuity at 5 per cent, yielding an annual income of $500. Suppose an annual property tax of 1 per cent is imposed. The tax will take $100, or 20 per cent of the income each year. Suppose now that another man, having $10,000, puts it in trust for fourteen years, after which time, the principal having doubled, he invests it in a perpetual annuity of $1,000 a year. Under the property tax he is taxed $100 the first year, but the second year, his capital having increased to $10,500, he pays a tax of $105. His tax increases each year till the fourteenth, after which it is $200 a year. The present value of all the taxes paid by the first man is $2,000, or 20 per cent of his capital. The present value of all the taxes paid by the second man is $3,428, or 34 per cent of his capital. That is, the man who does not use up his income, but invests it, is punished by an excessive tax.[a]

Now, the business of forestry is apt to be like the investment of the second man. The annual growth of the trees, instead of being taken each year as income, is left to increase the capital, till many years later when the timber is cut and the income begins to accrue. A property tax, strictly enforced, must inevitably place an excessive burden upon forests as compared with the ordinary investments yielding a regular annual income. It might easily take away from one-third to one-half of the entire net income, and very much more under certain conditions. This assumes, what the law clearly requires, that the forest be taxed each year on its true value, land and timber together.[b] Forestry should not be subjected to such an unjust burden.

It may be objected that as a matter of fact forests are not taxed on anywhere near their true value, and this practice should be recognized. But this does not relieve the situation much. Probably nothing more effectually discourages investment than uncertainty as to future costs. And whatever may be said of the present system of taxation, there can be no question of its arbitrariness and uncertainty. If to all the other risks of forestry we add uncertainty as to what the taxes are going to be, we can not blame investors for some hesitation in embarking on an enterprise which may have to pay taxes fifty years before the returns come in. And more than this; the investor can not safely base his calculations on the continuance of the present lenient administration of the property tax. As has been shown, the tendency to-day is toward a stricter enforcement of the law and a heavier burden of taxation.

There is a good deal of evidence from a variety of sources tending to show that in the few cases where forestry has already been seriously considered, the matter of taxation has been one of the most important items in the calculation and in many cases has been an insuperable obstacle.

The problem of forest taxation is, then, an important one, and a very practical one. It is safe to say that we can hardly hope to see the general practice of forestry by private owners until our methods of taxation are made more scientifically equitable and certain. The importance of this problem will necessarily increase as time goes on until it is properly solved. The subject, therefore, deserves the most careful and thorough investigation.

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[a] For a discussion of the economic principle here involved, cf. Fisher, "The nature of capital and income," Chapter XIV; especially pp. 249-255.

[b] For a further discussion of this matter based on mathematical examples, see Appendix to Chapter V, p. 613.

APPENDIX.

MATHEMATICAL ILLUSTRATION OF THE POSSIBLE BURDEN ON FORESTRY OF THE GENERAL PROPERTY TAX.

This appendix presents mathematical examples illustrating the statement of the text that the general property tax, strictly enforced according to the letter of the law, might easily take away a very large part of the income of the business of forestry. In these examples, the figures for cost of planting and value of standing timber are taken from an example worked out by the New Hampshire forestry commission.[a] The figures are for white pine in the State of New Hampshire. In all cases the rate of interest is assumed as 5 per cent.[b] The figures are for 1 acre of land.

Table A gives the following facts for five-year periods from the twentieth year to the seventieth: (1) The cost of planting, with accrued interest to the several dates; (2) the value of the standing timber at the several dates; (3) the net income of the forests, which is the difference between the value of the trees and the cost of planting, with interest to date; (4) the present expectation value of the forest if cut, respectively, at the three years which give the largest value; (5) the amount of the taxes with accrued interest to date—the taxes on the land and trees are given separately, the trees being exempt from taxation for the first 20 years; (6) the ratio of the taxes to the net income, given as a percentage; (7) the net income less taxes; and (8) the expectation value based on net income after deducting taxes. The tax rate is assumed at 1 per cent. It is assumed that the land is taxed on its full value—that is, on its present expectation value as a forest. In this example the most profitable year for cutting is the fiftieth. If cut in that year the present expectation value is $10.36. We have assumed that the land is taxed on a valuation of $10.

Some interesting results are evident from this table. In the first place, the taxes exceed the net income yearly up to the fortieth year and after the seventieth year. In the fiftieth year the ratio of taxes to net income is the smallest, being 39 per cent, and this year is still the most profitable cutting year, although the net income less taxes would be slightly greater if it were cut in the fifty-fifth year. Of course, the most important purpose of this table is to show that taxation under the assumed conditions will take 39 per cent of the total net income.

In order to show that the burden of taxation will still be very heavy, even though the land be valued considerably below its expectation value, Table B is presented. The figures in this table are the same as in Table A, with the exception that the land is assessed at $5. This is the value assumed by the New Hampshire forestry commission in their examples. In this case the taxes in the fiftieth year amount to 29 per cent of the net income, still a very high tax, although the land is assessed at only half of its true expectation value.

In Table C the circumstances are altered by assuming that the forest grows up without any cost of planting. Here also the most profitable cutting year is the fiftieth. Assuming that the forest is cut in this year the expectation value is $18, and we assume that the land is taxed on that value. The result shows a tax in the fiftieth year of 31 per cent of the net income.

In all these examples we have assumed a tax rate of 1 per cent, which is, of course, very low as compared with present prevailing rates, which are generally somewhere in the neighborhood of 2 per cent. One per cent was taken as representing roughly the percentage of present taxes to the true value of property. Since the total tax varies directly with the rate it is a simple matter to alter the figures in any of these examples to correspond to any given tax rate. As a single illustration of this Table D is presented, showing the result of a tax rate of 2 per cent under the conditions given in Table A. Obviously the taxes, and also the percentage of taxes to net income, are exactly doubled. The best that the forest owner can do is to cut in the fiftieth year and hand over 78 per cent of his net income in the form of taxes.

These examples, of course, show nothing as to the burden of taxation which may be expected under any particular conditions. They do show, however, the very heavy burden which may easily result from the general property tax under ordinary conditions.

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[a] Report of the New Hampshire Forestry Commission, 1905–6, p. 246.

[b] The question of the proper rate of interest for forestry investments is discussed in the Appendix to Chapter VI, p. 618, and in Chapter VI.

Examples of taxation.

TABLE A.

Year.	Cost of planting, with interest.	Value of timber.	Net income.	Expectation value.	Taxes on land value, $10.	Taxes on trees.	Total taxes.	Ratio of taxes to net income, per cent.	Net income, less taxes.	Expectation value, taxes deducted.
1	$7.00				$0.10		$0.10			
20	18.57	$4.41	−$14.16		3.30		3.30		−$17.46	
25	23.70	9.44	− 14.26		4.78	$0.22	5.00		− 19.26	
30	30.25	19.98	− 10.27		6.64	.78	7.42		− 17.69	
35	38.61	41.52	2.91		9.04	2.11	11.15	383	− 8.24	
40	49.28	82.50	33.22		12.08	5.02	17.10	51	16.12	
45	62.90	133.66	70.76	$8.86	15.98	11.01	26.99	38	43.77	$5.48
50	80.27	189.00	108.73	10.36	20.94	21.46	42.40	39	66.33	6.32
55	102.45	238.28	135.83	9.99	27.28	37.83	65.11	48	70.72	5.20
60	130.75	286.77	156.02		35.36	61.39	96.75	62	59.27	
65	166.88	334.43	167.55		45.68	94.20	139.88	83	27.67	
70	212.98	385.02	172.04		56.86	138.68	197.54	115	− 25.50	

TABLE B.

Year.	Net income.	Taxes on land value, $5.	Taxes on trees.	Total taxes.	Ratio of taxes to net income, per cent.	Net income, less taxes.	Expectation value, taxes deducted.
1		$0.05		$0.05			
20	−$14.16	1.65		1.65		−$15.81	
25	− 14.26	2.39	$0.22	2.61		− 16.87	
30	− 10.27	3.32	.78	4.10		− 14.37	
35	2.91	4.52	2.11	6.63	228	− 3.72	
40	33.22	6.04	5.02	11.06	33	22.16	
45	70.76	7.99	11.01	19.00	27	51.76	$6.48
50	108.73	10.47	21.46	31.93	29	76.80	7.31
55	135.83	13.64	37.83	51.47	38	84.36	6.29
60	156.02	17.68	61.39	79.07	51	76.95	
65	167.55	22.84	94.20	117.04	70	50.51	
70	172.04	29.43	138.68	168.11	98	3.93	

TABLE C.

Year.	Value of timber, no costs.	Expectation value.	Taxes on land value, $18.	Taxes on trees.	Total taxes.	Ratio of taxes to income, per cent.	Net income, less taxes.	Expectation value, taxes deducted.
1			$0.18		$0.18			
20	$4.41		5.94		5.94	135	−$1.53	
25	9.44		8.60	$0.22	8.82	93	.62	
30	19.98		11.95	.78	12.73	64	7.25	
35	41.52		16.27	2.11	18.38	44	23.14	
40	82.50		21.74	5.02	26.76	32	55.74	
45	133.66	$16.73	28.76	11.01	39.77	30	93.89	$11.75
50	189.00	18.00	37.69	21.46	59.15	31	129.85	12.37
55	238.28	17.52	49.10	37.83	86.93	36	151.35	11.13
60	286.77		63.65	61.39	125.04	44	161.73	
65	334.43		82.22	94.20	176.42	53	158.01	
70	385.02		105.95	138.68	244.63	64	140.39	

Examples of taxation—Continued.

TABLE D.

Year.	Net income.	Total taxes.	Ratio of taxes to net income, per cent.	Net income, less taxes.	Expectation value, taxes deducted.
	....	$0.20	....	....	....
1	−$14.16	6.60	....	−$20.76	....
20	− 14.26	10.00	....	− 24.26	....
25	− 10.27	14.84	....	− 25.11	....
30	2.91	22.30	766	− 19.39	....
35	33.22	34.20	103	− .98	....
40	70.76	53.98	76	16.78	$2.10
45	108.73	84.80	78	23.93	2.28
50	135.83	130.22	96	5.61	.42
55	156.02	193.50	124	− 37.48	....
60	167.55	279.76	167	−112.21	....
65	172.04	395.08	230	−223.04	....
70					....

CHAPTER VI.

THE PRINCIPLES OF SCIENTIFIC FOREST TAXATION.

The foregoing discussion has shown the fundamental weakness of the present methods of taxing timber lands and the necessity of adopting some scientific system which will secure both equity and certainty. It is now necessary to inquire into the fundamental principles which must be the basis of any correct method of taxing timber lands.

We may assume, without much danger of controversy, that taxation should be based on income or earning power. The tax on income may be collected at the time the income accrues, or it may be in the form of an annual tax on the capital value of the income. If the rates of the income tax and the capital tax bear the proper relation to each other, those two ways of applying the tax produce identical results. For example, if the interest rate is 5 per cent, an income tax of 20 per cent is equivalent to an annual capital tax of 1 per cent, provided the business taxed is earning a regular annual income. In general the rate of the capital tax is equal to the rate of the income tax multiplied by the rate of interest.

In the case of forests, the tax based on income may be applied in either of two ways, (1) as a tax on the yield whenever any timber is cut, or (2) as an annual tax on the present capital value of the forest, based on all its expected future incomes and expenditures, what the foresters call "expectation value." To illustrate by a single example, suppose that a forest is so managed as to yield a net income of $150 sixty years from to-day, and again every sixty years thereafter, without any cost for planting. If interest is at 5 per cent, a simple calculation will show that the present expectation value of the forest is $8.47. Suppose it is desired to tax this forest at the rate of 20 per cent of its net income. This may be accomplished either by a tax of 20 per cent of the net yield whenever it occurs, or by an annual tax of 1 per cent of the expectation value. The first would mean a tax of $30 paid every sixty years when the timber was cut. The second would mean a tax of 8½ cents paid every year. The present value of these two taxes—that is, $30 paid sixty years from date and every sixty years thereafter, and 8½ cents paid every year, beginning at once—is exactly the same.

The above is an example of a forest managed to produce a sustained periodic yield; that is, the timber is cut at long intervals, the forest being renewed after each cutting so as to produce about the same yield after each rotation period forever. Forests may also be managed so as to produce a sustained annual yield. In this case, timber is cut annually, about the same amount each year, and the forest is maintained without deterioration forever. And finally, forests may not be managed according to any system of forestry, the yield being purely irregular.

Obviously the tax on yield when cut may be applied to any forest, whatever the system of management, or even where no systematic management is employed. This method simply takes a certain part of the yield whenever any timber is cut. On the other hand, the tax on expectation value is more complicated. It requires the calculation of present value based on all future expected incomes and expenses. And in the case of the forest with irregular yield it is impossible to apply this method at all, for there is no way of calculating the expectation value.[a]

A matter of the utmost importance in the case of the tax on expectation value is the rate of interest at which the calculation is made. That a good deal depends on what rate is selected may be realized from the single fact that if in the above example 4 per cent had been used instead of 5, the annual tax would have been 16 cents instead of 8¼ cents. A change of a single unit in the rate of interest may double or even treble the amount of the tax. Evidently the rate of interest is the crux of the whole theory of the tax on expectation value. This subject has never received the thorough investigation which its importance deserves. A short discussion is given in the appendix to this chapter. The following very brief suggestions are offered here.

Writers of the technical works on forestry are inclined to capitalize forest investments at very low rates of interest, 2½ or 3 per cent being usually adopted. The writer is convinced that these rates are too low, at least for American conditions. To mention only two reasons for this belief: In the first place, the risk of fire is so great that no insurance company will accept it. In the second place, forestry is peculiar in the long interval of time which must generally elapse before the investment begins to yield an income. It is a well-known psychological fact that such an income will be discounted at a higher rate of interest than those whose enjoyment is less remote.

Without mentioning other reasons for a high rate, the writer is convinced that, as compared with ordinary investments, forest investments must be capitalized at a relatively high rate of interest. Five per cent is certainly not too high. It is very probably too low. This question must be carefully considered in applying a tax on expectation value.

The selection of the rate of the forest tax, whether a tax on yield when cut or on expectation value, is simple theoretically. If it is desired to place the same relative burden on forests as on other kinds of wealth, the rate on expectation value should be the same as the actual rate of the general property tax on true value;[a] the rate on yield when cut is the quotient of the rate of the property tax divided by the rate of interest. If it is desired to offer special inducements to forestry by a lower burden of taxation, the above rates may be reduced in any desired degree.

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[a] For a more extended discussion of the theory of forest taxation, with numerous mathematical examples, see Appendix to Chapter VI, p. 618.

In order to avoid uncertainty and arbitrary taxation, the rate of the forest tax should be determined by a state officer or board, the rate to apply in all parts of the State; or the State may merely establish a maximum rate, leaving to any town the liberty to levy a lower rate if desired.

It has been shown that in general the scientific principles of forest taxation may be applied either as a tax on yield when cut, or as a tax on the capital value of the forest. It now becomes necessary to weigh the relative merits of these two methods of taxation with particular reference to American conditions.

No sooner is the question raised than the answer forces itself upon us that the tax on expectation value is not capable of general application in the United States. This method depends on the general practice of forestry, whereas in America the practice of forestry is the rare exception outside of the public reserves. This method requires the existence of accurate yield tables for the various species of trees and for different parts of the country. Only the smallest beginning has yet been made toward the construction of such tables for America. This method can not be applied to forests producing an irregular yield. Yet nearly all the forests in the United States are of this class.

These considerations alone show the impossibility of applying the tax on expectation value in America at the present time and for a long time to come. On the other hand, there are some positive considerations in favor of the tax on yield which are of the greatest importance. In the first place, the tax on yield avoids the whole problem of the rate of interest, which has been shown to be at once the most important and the most difficult theoretical factor in the tax on expectation value. When a forest is taxed on its yield, the value of the yield and the value of the tax will bear the same relation to each other, no matter what the rate of interest, since both are necessarily discounted at the same rate. For example, if a forest yields $150 net income every sixty years and is taxed 20 per cent of the yield, or $30 every sixty years, the present value of the tax of $30 will always be one-fifth of the present value of the yield of $150, no matter what rate is used in discounting. The importance of this argument in favor of the tax on yield can hardly be exaggerated.

Again, the use of the tax on yield relieves us of the necessity of estimating the future prices of timber. All calculations of expectation value are rendered more or less untrustworthy by the great uncertainty as to future prices of timber. All the estimates on this subject must be a matter of more or less skillful guesswork. The objection to a tax based on such calculations is obvious. On the other hand, future prices of timber are a matter of indifference as regards the principles of the tax on yield. Since the tax is a certain part of the yield, changes in price affect both the yield and the tax in the same way. Here also is a most weighty argument in favor of the tax on yield.

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[a] For example, if the rate of the general property tax is 2 per cent, and property is usually assessed at a fixed ratio of 50 per cent of its true value, the rate of the tax on true value is 1 per cent.

Similarly, by basing the tax on yield, we eliminate the element of risk from the tax problem. The danger of loss by fire, etc., is so great that forestry investments are at best decidedly uncertain. This risk, as is shown above, should be taken into account in determining the rate of interest. But no one can estimate the degree of risk with any approach to accuracy, and no allowance in the rate of interest can prevent serious injustice being done in individual cases. An owner may have been paying taxes on his forest for fifty years, only to see the yield at last wiped out by a destructive fire. Moreover, such a system would act as a deterrent influence against forestry investments. When the annual taxes to be paid are a sure thing, while the yield to be obtained after fifty years is very uncertain, we can not blame the investor for hesitating. All this is avoided by the tax on yield. Forest investments will still be subject to risk, but the risk will not be complicated by taxation. Taxes are paid on the yield, and if the yield is destroyed by fire the taxes are thereby automatically remitted.

Another argument, though of less importance, is worthy of mention here. In certain cases the tax on expectation value might lead to premature cutting. If an owner became financially embarrassed, so that the payment of his annual tax became a matter of difficulty, he might be led to cut immature timber to get money to pay his taxes. The tax on yield would not have this influence.

We conclude, therefore, that the superiority of the tax based on yield when cut is demonstrated beyond question. We may therefore dismiss the tax on expectation value, and confine the discussion of practical applications and administrative problems to the tax based on yield when cut.

APPENDIX.

THE THEORY OF FOREST TAXATION.

I. THE THEORY OF FORESTRY AND FOREST TAXATION.

Assuming that taxation should be based on income or earning power, any given tax on income-producing wealth may be levied either as a tax on the net income whenever it accrues, or as an annual tax on the capital value of all the expected future net incomes.

In order to have a sound theoretical basis for the study of forest taxation, it will be necessary to inquire into the economic character of the business of forestry. Assuming that some regular system of forest management is in operation, the receipts and expenditures of a forest occur at different times, according to the way in which the forest is managed. In order to express the problem in mathematical terms, the following notation is used:[a]

Let p = the rate of interest.
Let r = the number of years in the rotation period; i. e., the number of years between successive major cuttings.
Let Y_r = the value less cost of harvesting of each final or major yield, realized every r years.
Let T_a, T_b . . . T_q = the value less cost of harvesting of the intermediate yields from thinnings, etc., occuring in the years a, b, . . . q. Each of these thinnings occurs during every rotation, that is, every r years. Thus the first thinning T_a occurs after a years, again after $a + r$ years, again after $a + 2r$ years, etc.
Let m = the annual value of any annually recurring incidental revenue, as, for example, grazing fees, rent of the forest for hunting, etc.

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[a] Cf. Schlich, Manual of Forestry, Vol. III, third edition, pp. 122-126; Fernow, Economics of Forestry, pp. 215-216; etc.

Let M = the capitalized value of the annual incidental revenue; that is, $M = \frac{m}{.0p}$.

The quantity *m* (or M) may generally be disregarded, or may be assumed to have been deducted from the annually recurring expenses *e* (or E).

Let *c* = the cost of formation (planting, etc.) which has to be incurred at the beginning of each rotation, occurring, therefore, every *r* years. We may assume that this cost is the same at the beginning of each rotation.

Let *e* = the annual value of all annually recurring expenses, as cost of administration, etc. For our problem, *e* does not include taxes.

Let E = the capitalized value of the annual expenses; that is, $E = \frac{e}{.0p}$.

Let S_e = the expectation value ("soil expectancy value") of the forest; that is, "the sum of the present values of all returns expected from the soil in the course of time, less the present value of all expenses which must be incurred to obtain these returns,"[a] at the beginning of the rotation period, or just after one of the cuttings, Y_r;

The expectation value, or present capitalized value, of a forest in which the above items of revenue and expenditure occur is then represented by the following formula:

$$S_e = \frac{Y_r + T_a\,(1.0p)^{r-a} + \;.\;.\;.\;.\;.\; + T_q\,(1.0p)^{r-q} - c(1.0p)^r}{1.0p^r - 1} - E.^{b}$$

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[a] Schlich, p. 122.

[b] For those not familiar with the mathematics involved in the above formula, the following explanation may be of service: All the items of revenue and expense are reduced to their present value at the beginning of the rotation period; i. e., just after a final harvest has been cut and before the planting for the next harvest has been made. The final income Y_r will occur after a period of *r* years, and again every *r* years forever. The present value of such an income is, according to a well-known mathematical formula, $\frac{Y_r}{1.0p^r-1}$. The first intermediate revenue appears in the year *a*, and is represented by T_a. In the year *r* it will amount with accumulated interest to $T_a(1.0p)^{r-a}$. The same revenue will appear again after *a*+*r* years, and so on every *r* years forever. The present value of such an income is $\frac{T_a(1.0p)^{r-a}}{1.0p^r-1}$. Likewise the value of the next thinning, coming in year *b* and every *r* years thereafter, is $\frac{T_b(1.0p)^{r-b}}{1.0p^r-1}$; and so on to the last thinning before the final harvest, T_q, whose present value is $\frac{T_q(1.0p)^{r-q}}{1.0p^r-1}$. The cost of planting, etc., is *c*. With accumulated interest this cost will amount, in the year *r*, to $c(1.op)^r$. It will occur again in the year *r* and every *r* years thereafter forever. The present value of all these expenses is $\frac{c(1.0p)^r}{1.0p^r-1}$. The regular annual expenses *e* occur every year forever. Their present value is therefore $\frac{e}{.0p}$=E. The sum of the present value of all these items of revenue less the present values of all the items of expense gives the present value of the forest or its expectation value. Thus:

$$S_e = \frac{Y_r}{1.0p^r-1} + \frac{T_a(1.0p)^{r-a}}{1.0p^r-1} + \;.\;.\;.\;.\; + \frac{T_q(1.0p)^{r-q}}{1.0p^r-1} - \frac{c(1.0p)^r}{1.0p^r-1} - E.$$

This expression reduces to the formula of the text,

$$S_e = \frac{Y_r + T_a(1.0p)^{r-a} + \;.\;.\;.\;.\; + T_q(1.0p)^{r-q} - c(1.0p)^r}{1.0p^r-1} - E.$$

This is the general formula representing all possible systems of forest management. When applied to particular kinds of management the formula may be changed by the omission of certain of its terms. Where no regular system of forestry is practiced, the formula obviously has no application. For the sake of clearness we may classify forests according to their management as follows:

I. Producing a sustained annual yield.
II. Producing a sustained periodic yield,
    1. Clear cutting.
        a. Reproduced by planting.
        b. With natural reproduction.
    2. Selection cutting.
III. Producing an irregular yield (where systematic forestry is not practiced).

I. First, and simplest of all, we have the case of the forest managed so as to produce a sustained annual yield.[a] In this case a regular income is obtained each year, presumably forever. Here r is 1; there is no cost of planting, and hence c is 0; T and A are disregarded, being merged in Y; and we have simply an annual net income representing the difference between the annual yield from all sources and the annual expenses of all kinds. Let this annual net yield=Y. Then the capital value of the forest is obtained from the equation,

$$S_e=\frac{Y}{.0p}.$$

For example, suppose a forest produces an annual net income of 50 cents an acre.[b] . In this and the following examples we assume the rate of interest is 5 per cent. Then $p=5$; $v=0.50$; $S_e=\frac{0.50}{0.05}=10$. That is, we have a forest yielding a net annual income of $0.50 per acre and whose capital value is therefore $10 per acre.[c] This case is like the ordinary business investment.

II. The forest which produces a sustained periodic yield resembles the case just described in that the yield is sustained and fairly regular. It differs in that the principal yield occurs not every year but at longer intervals. The timber may be removed either by clear cutting or by selection cutting. In the first case the timber is practically all removed, and the interval which must elapse before another cutting is the time necessary for the trees to grow to the most profitable cutting age. This case is subdivided according as the forest is renewed after cutting by planting or by natural reproduction.

1, *a*. When a forest is made to produce a sustained periodic yield by clear cutting, reproduced by planting, we have the case to which the general formula applies without change, all the terms being present. Forestry in America, however, has not progressed far enough to enable us to assign values to the terms T and E with any approach to accuracy. It is customary, therefore, to disregard these terms; they, of course, tend to neutralize each other. Indeed, with the present available yield tables and records of planting, the values assigned to Y and c must be more or less arbitrary. The formula thus becomes

$$S_e=\frac{Y_r-c\ (1.\,0p)^r}{1.\,0p^r-1}.$$

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[a] Of course a forest which as a whole produces a sustained annual yield may be in its various parts managed in any of the other ways. So long as the forest as a whole produces a sustained annual yield, the management of its various parts is a matter of no concern to the problem of taxation, provided a single jurisdiction taxes the whole forest.

[b] The numerical values to be given to the terms in the formula are different, of course, for each species and each locality. This example and those that follow are more or less arbitrary. Their purpose is to illustrate the theory, not to show what may be expected from forestry in any particular case. They are, however, based to a certain extent on actual cases, and are intended to approach with a fair degree of accuracy average conditions in the United States.

[c] The figures in this example are quite conservative. For an example approaching the one given, see Forest Service Bulletin No. 26, p. 49, first example.

For example, suppose a piece of bare or cut-over land is planted at a cost of $7 per acre. The timber is cut after sixty years, when the net value of the yield is $300 per acre. The land is then replanted, and the process repeated indefinitely. Then, $r=60$; $p=5$; $Y_r=300$; $c=7$.

$$S_e=\frac{300-7(1.05)^{60}}{1.05^{60}-1}=\frac{300-131}{17.7}=\frac{169}{17.7}=9.55.$$

This forest therefore yields a net income of $169 per acre every sixty years, and its capital value (or expectation value) is $9.55.[a] The annual income of $9.55 at 5 per cent is $0.48; that is, the forest in question, yielding $169 net every sixty years, is worth exactly the same per acre as a forest or other investment yielding $0.48 every year.[b]

1, *b*. The forest which is made to produce a sustained periodic yield by clear cutting, with natural reproduction, differs from the case just described only in the absence of the item of cost of planting. The formula is, therefore,

$$S_e=\frac{Y_r}{1.0p^r-1}.$$

For example, suppose a forest will produce a net yield of $150 per acre every sixty years, by clear cutting and natural reproduction. Then $r=60$; $p=5$;

$$Y_r=150. \quad S_e=\frac{150}{1.05^{60}-1}=\frac{150}{17.7}=8.47.$$

That is, the forest yields a net income of $150 per acre every sixty years, and its capital value is $8.47 per acre.[c] This forest is worth the same as a forest yielding $0.42 per acre every year.

2. The next case in our classification is the forest producing a sustained periodic yield by selection cutting. Here, instead of taking off all the timber, only a part is removed, the time for removal being selected according to some rule which perpetuates the forest and permits the return, after a certain interval, for another cutting by the same method. The interval is apt to be chosen so that about the same yield will be obtained from each cutting. The forest is perpetuated naturally, and there is no cost for planting. The formula for this case is the same as for the preceding (1, *b*.),

$$S_e=\frac{Y_r}{1.0p^r-1}$$

For example, suppose a forest, under the method of selection cutting, produces a net yield of $15 per acre, and that an equal yield can be obtained every thirty years by the same method of cutting.

$$\text{Here } r=30;\ p=5;\ Y_r=15. \quad S_e=\frac{15}{1.05^{30}-1}=\frac{15}{3.32}=4.52.$$

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[a] These figures represent a forest in good condition. For examples resembling the above, cf. N. H. Forestry Commission, Report 1905–1906, pp. 235–249; Conn. State Forester Report, 1907, pp. 254–258.

[b] We are here disregarding any extra risk of loss in the case of the planted forest and also the whole question of the proper rate of interest at which to discount forestry investments. These questions are discussed in Chapter VI, pp. 615–618, and in the appendix to Chapter VI, pp. 618–626.

[c] The figures given in the example are probably rather conservative for a first-class forest.

That is, the forest yields a net income of $15 per acre every thirty years, and has a capital value of $4.52 per acre.[a] This forest has the same value as one which yields $0.23 per acre every year.

III. The third group of forests contains all those where forestry is not practiced. There being no regular system of management, it is of course impossible to apply a formula based on regular sustained yield, and accurate calculations of future yield or expectation value are out of the question.

A tax on forest lands, based on earning power, may be applied theoretically in either of two ways, (1) as a tax on income, taxing the net yield of the forest when the timber is cut, or (2) as an annual tax on capital value, the capital value being the true expectation value based on all expected future incomes and expenses. Provided the two tax rates bear the proper relation to each other, the resulting tax burden will be exactly the same, whichever method of taxation is employed.[b] The relation between the two tax rates is expressed by the following equation, where t_i is the rate of the income tax, t_c the rate of the tax on capital value, and p the rate of interest:

$$t_c = t_i \times 0p.$$

For example, if the rate of interest is 5 per cent, a tax of 20 per cent on yield when cut is equivalent to a rate of 1 per cent on capital value.

The tax on yield when cut applies without distinction to all kinds of forests. For this tax it is not necessary to distinguish the different kinds of management, or even to make any special provision for the forest which is not managed under any regular plan. Each forest is simply taxed on its yield whenever any timber is cut.

The tax on capital value, on the other hand, requires the computation of expectation value. This computation differs according to the character of management, and in the case of the forest subject to no regular management is impossible.

The operation of a tax on forests based on these principles may be made clear by a mathematical example corresponding to each of the examples of forest management given above.

For our present purpose we may assume that forests are to be taxed equitably in comparison with other kinds of wealth which are under the general property tax. The proposition to offer special encouragement to forestry by means of taxation at a lower rate than other kinds of wealth have to bear is discussed elsewhere. Here we assume the ideal of an equal burden of taxation on all kinds of wealth in proportion to income. Let us assume, by way of example, that other forms of wealth are being taxed at the average rate of 1 per cent of the true value, under the general property tax.[c]

The California tax commission in 1906 adopted 1 per cent as representing the average burden of the general property tax on wealth in general in California. "Report of the Commission on Revenue and Taxation of the State of California, 1906," p. 98-100.

With an interest rate of 5 per cent, this is equivalent to a tax of 20 per cent upon net income. Applying the two methods of taxation in turn to each of the examples of forest management given above, we have the following result:

(1) The case of the forest producing a sustained annual yield is the simplest. The net income is $0.50 per acre annually. Its capital value is $10 per acre. If taxed on yield, this forest would pay an annual tax of 20 per cent of $0.50, or $0.10 per acre. If taxed on capital value, it would pay annually 1 per cent

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[a] These figures are probably rather conservative. For a similar example, cf. Forest Service Bulletin No. 26, p. 49, second example. This example was a forest of spruce with some hard woods, only the spruce being figured in the value of the cut. A number of other examples more or less similar to the one in the text may be found in the various forest working plans issued by the Forest Service and printed in its Bulletins.

[b] This assumes also, of course, that the rate of interest employed in the calculation of expectation value is the correct one for the circumstances.

[c] In Connecticut the average tax rate in 1907 was 1.3 per cent on an assessed valuation of 85 per cent. This is equivalent to a rate of 1.105 per cent on the true value. "Information relative to the Assessment and Collection of Taxes, 1908." Published by the Connecticut tax commissioner, pp. 20-21.)

of $10, or $0.10 per acre. The tax is evidently the same, whichever basis of assessment is employed.

(2) The next example is that of the forest producing a sustained periodic yield by clear cutting, reproduced by planting. The net income, or the value of the cut less expenses, is $169 per acre, and this income occurs every sixty years. The capital value of the forest is $9.55 per acre. If taxed on yield, this forest would pay a tax of 20 per cent of $169, or $33.80 per acre, paid every sixty years at the time of cutting. If taxed on capital value, the tax would be 1 per cent of $9.55, or $0.095 per acre, paid annually. The present value of $33.80 paid sixty years from date and every sixty years thereafter (interest being at 5 per cent) is $\frac{33.8}{1.05^{60}-1}=\frac{33.8}{17.7}=\$1.91$. The present value of $0.095 paid annually forever is $\frac{0.095}{0.05}=\$1.90$. The mathematical identity of the two methods is evident.

(3) The forest producing a sustained periodic yield by clear cutting, with natural reproduction, differs from the preceding case only in the absence of an item of cost of planting to be deducted from the yield. In the example given the net yield is $150 per acre, occurring every sixty years. The capital value is $8.47 per acre. The tax based on yield would be 20 per cent of $150, or $30, paid every sixty years. The tax on capital value would be 1 per cent of $8.47, or $0.085, paid annually. The present values of these two taxes are, respectively, $\frac{30}{1.05^{60}-1}=\$1.69$, and $\frac{0.085}{0.05}=\$1.70$.

(4) Where the forest produces a sustained periodic yield by selection cutting, the expectation value is computed by the same formula as in the preceding case. In the example given the net income is $15 per acre, occurring every thirty years. The capital value is $4.52 per acre. The tax based on yield would be 20 per cent of $15, or $3, paid every thirty years. The tax on capital value would be 1 per cent of $4.52, or $0.045, paid annually. The present values of these two taxes are, respectively, $\frac{3}{1.05^{30}-1}=\$0.90$ and $\frac{0.045}{0.05}=$ $0.90, demonstrating the identity of the two methods of assessment.

(5) Where no regular management is employed, and the yield comes at irregular intervals and in irregular amounts, it is obvious that mathematical examples would be of no service. It is equally obvious that this kind of forest presents no theoretical difficulties in the case of a tax on yield when cut, but that the annual tax on capital value is impossible, since there is no way of calculating expectation value.

Assuming that the correct basis of taxation is income, and that timber lands are to bear the same relative burden of taxation as other kinds of wealth, the theory of the correct taxation of timber lands is simple. The foregoing examples are sufficient to demonstrate this. Forest lands may be taxed in one of two ways: (1) Levy a tax on the value of the net yield whenever any timber is cut, at a determined rate, assumed to represent fairly the burden of taxation on other kinds of income. This method applies without distinction to the forest producing an annual sustained yield and to the one whose yield is periodic. The difference is that in the one case the tax is paid annually; in the other it is paid at regular but longer intervals. It also applies without difficulty to the forest whose yield is irregular. (2) Estimate the capital value of the forest (i. e., its expectation value based on all future expected incomes and expenses) and levy the tax at a determined rate equivalent to the income tax rate which represents fairly the burden of taxation on other kinds of wealth. The rate of the tax on capital value is the rate of the income tax multiplied by the rate of interest. This method also applies to any forest which is producing a sustained annual or periodic yield. In the case of the annual sustained yield, the calculation of capital value is very simple, the capital value being the quotient of the annual income divided by the rate of interest. In the case of the periodic yield the problem is more complicated, requiring the calculation of the present expectation value of the forest based on all future expected revenues and expenses. This method can not be used in those cases where no regular management is in operation, or where the yield is so irregular as to prevent the accurate calculation of expectation value.

II. THE RATE OF INTEREST.

A most important factor in the calculation of expectation value is the rate of interest. In the examples in Section I of this appendix 5 per cent has been chosen as the rate of interest, and this rate has served as well as any other for the illustration of theoretical principles. The selection of this particular rate, however, has not been meant to carry with it any assumption that 5 per cent is in fact the correct rate at which to capitalize forest investments, nor that the selection of the rate of interest is a matter of slight importance. It is really of the most vital importance; indeed, it is hardly an exaggeration to say that it is the crux of the whole theory of the tax on expectation value. Its importance can readily be seen by a glance at the following table, which shows the expectation value and the amount of the annual tax on capital value in each of the examples discussed above, where different rates of interest are used in the calculation:

Tax on expectation value.

Rate of interest.	Example 1.		Example 2.		Example 3.		Example 4.	
	Expectation value.	Tax.	Expectation value.	Tax.	Expectation value.	Tax.	Expectation value.	Tax.
Per cent.								
3	$16.67	$0.17	$52.92	$0.53	$30.67	$0.31	$10.49	$0.10
4	12.50	.13	23.84	.24	15.79	.16	6.70	.07
5	10.00	.10	9.55	.10	8.47	.08	4.52	.05
6	8.33	.08	2.16	.02	4.69	.05	3.16	.03
7	7.14	.07	−1.87	−.02	2.63	.03	2.27	.02
10	5.00	.05	−6.04	−.06	.49	.005	.91	.009

The results of using different rates of interest are most remarkable in example 2, which is due to the presence of an original cost of planting, which increases enormously as the rate of interest is raised, until at 7 per cent this cost eats up the entire yield of the forest. This is the only case in which the expectation value can become negative. The other examples, however, are scarcely less eloquent in their testimony to the overwhelming importance of the rate of interest. When we see that a change of one unit in the rate of interest may double or even treble the amount of the tax, we begin to realize that if our tax system is to be based on expectation value all our search after an equitable tax will be a farce unless means are taken to correctly determine this factor of the problem.

In the brief time which the writer has had at his disposal for the preparation of this report it has been impossible to give the subject the thorough investigation which its importance deserves. Indeed, for all the practical purposes of this report, such a study would have little bearing, since, as is shown in the text of Chapter VI, the tax on expectation value must be rejected on other grounds as not capable of practical application under present American conditions. This subject will therefore be passed with the following brief suggestions:

That the question has never received proper investigation is evident from the character of its discussion in the technical works on forestry. In working out problems of expectation value, these works use rates of interest which are almost certainly too low, if forestry is to be considered on a commercial basis. For example, Endres uses 3 per cent in calculating expectation value.[a] Schlich, after a discussion covering three pages, decides on 2½ per cent, basing his decision mainly on the fact that at the time he was writing that was the rate paid by British consols.[b] Fernow argues in favor of a low rate of interest,[c] on the grounds that interest rates are likely to fall in the future, that forests will generally be a safe investment, and that the price of wood is likely to rise. He concludes that, since trust companies and savings banks are making long-time investments at 3 and 3½ per cent, we may safely use those rates or even lower ones in calculating the value of forest investments. In an example on another page, however, he uses 5 per cent.[a]

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[a] Endres, "Die Besteuerung des Waldes, Forstwissenschaftliches Centralblatt, Sept.–Oct., 1899," p. 496.

[b] Schlich, "Manual of Forestry," Vol. III, 3d ed., pp. 113–116.

[c] Fernow, "Economics of Forestry," pp. 214–215.

These examples will illustrate the reasoning commonly employed on this subject, the conclusion being that forest investments should be capitalized at a relatively low rate of interest, not higher than 2½ or 3 per cent. This conclusion may possibly be valid for the settled conditions of forestry which prevail in certain parts of Europe, though even this is open to question. But for conditions such as prevail in America such reasoning and such a conclusion can not be accepted.

Instead of being lower than the ordinary commercial rate, the writer is satisfied that the rate of interest for forest investments should be fully as high as the rate on ordinary investments, or even considerably higher. Forestry is a business of a peculiar character. In the first place, the risk is very great. The danger of fire is so great that no insurance company will take the risk. There is also the risk of injury by insects, wind, etc. These risks must be taken account of in the rate of interest, and it will require more than a slight increase in the rate to fully compensate for them. To put forest investments on a par with government bonds and the better class of trust company and savings bank investments is absurd under present American conditions.

But the circumstance which above all others makes forestry a business by itself is the very long period which must generally elapse before the investment begins to yield an income. The investment of $1,000 in a perpetual annuity of $30 or $40 a year is one thing; to put capital into an investment from which no income is to be expected for fifty or sixty or even one hundred years (very probably not till after the death of the investor) is a very different thing. Innumerable investments of the first kind are being made every day, and we can determine the prevailing rate by a glance at the dealings on the stock exchange. Investments of the second kind are so rare that we are unable to say from actual dealings what the rate should be. The comparison of future with present good, on which rates of interest depend, is a psychological process, and is influenced by a multitude of considerations. One of the most important of these is the remoteness of the future good, and it is certain that the rate at which men discount future events tends to increase with the remoteness of the event. Many a man who is satisfied with an investment which yields him 3 or 4 per cent at once would not consider for a moment an investment at the same rate whose income was to commence sixty years from date. It is safe to say that, other things being equal, men will not be tempted by forestry investments unless the rate of interest is considerably higher than that of investments whose income begins at once. It is clear that we can not put forestry on a par with the better investments of trust companies and savings banks.

Even a brief examination will show the weakness of some of the arguments cited above in favor of a low rate of interest. The assumption that the rate of interest tends to fall is belied by recent history. Schlich, writing in 1895, based his rate on British consols, which paid 2½ per cent, and he has made no change in this paragraph in his third edition published in 1905. But to-day British consols yield 3 per cent on their market price, and French and German government bonds yield even higher returns. Fernow's book was published in 1902, yet even this brief time has seen a considerable rise in interest rates, and many a savings bank to-day is paying 4 per cent to depositors. On account of the depreciation of our monetary standard, resulting from the tremendous production of gold, interest rates have been rising for the past decade, and the same influence is more than likely to cause a further rise in the future. So far as the future of the rate of interest is concerned, the effect should be to cause a higher rather than a lower rate on deferred incomes.

That the price of wood is likely to rise, and so increase the profits of forestry, can not be denied. This circumstance, however, should not properly enter into the determination of the rate of interest. It should rather be taken account of in estimating the value of the future yield of the forest (the terms Y and T in the formula). Any proper estimate of the value of future yield will take

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[a] Fernow, "Economics of Forestry," p. 251.

into account the probable increase in the price of timber. This factor being thus accounted for, there is no reason for lowering the rate of interest on this account.

We may conclude, then, that as compared with ordinary investments, the income of forestry should be capitalized at a relatively high rate of interest. Further study would probably show that, if the rate of five per cent adopted for the examples above is not the correct one, it errs in being too low rather than too high.

CHAPTER VII.

PRACTICAL CONSIDERATIONS AND PROBLEMS OF ADMINISTRATION.

The practical difficulties in the way of any plan of tax reform in the United States are tremendous. The path toward scientific forest taxation is sure to be strewn with obstacles, more or less serious. The tax on yield when cut has been advocated as an underlying principle. In putting this principle into operation no two States would necessarily adopt exactly the same administrative methods or machinery. This report obviously can not go into local conditions or into minute details of administration. We must, however, discuss some of the general problems of administration and look into some of the serious practical objections which may be urged against the tax on yield when cut. The following suggestions are offered:

I. THE BASIS OF ASSESSMENT.

Shall the tax be assessed upon the gross or upon the net yield of the forest? The ideal basis for any tax is net income. Practically it is often advisable to use gross income. In the case of forest taxation the stumpage value of the timber cut would probably be the best basis of assessment. In most cases this comes very near the net yield, and it is also the simplest basis for administrative purposes.

II. EQUALIZING LOCAL INCOME.

The first difficulty in the way of the tax on yield is that it would apparently result in an irregular and uncertain revenue for many towns and counties. Three alternative plans are suggested for meeting this difficulty.

(*a*) Let the tax be administered by the State. Let a rough estimate be made of the probable average annual yield of the forests in each town or county. Applying the tax rate to this average yield will give approximately the average annual revenue which the town or county may expect from its forests. Then let this amount be paid to each town or county annually by the State. Whenever any timber was cut in the town or county the State would collect the tax. An account would be kept by the state treasurer in which the town or county would be debited with the annual payments to it from the State, and credited with all taxes collected from the forests within its borders. At stated intervals a balance would be struck between these debits and credits with accumulated interest to date. The balance on either side would be carried forward to the next time of settling. A large balance on either side would be avoided by altering the amount of the annual payments from time to time as experience showed they were too high or too low. Such a plan would not require an exact calculation of expectation value, since no permanent injustice could result from errors in the calculation of the annual payments from the State to the towns or counties. This plan makes the State the administrator of the forest tax and the banker for the towns or counties, thus guaranteeing to each a fairly regular income, probably more regular than the income from taxation of forest lands to-day. The State itself has a large enough territory, so that the tax would produce a fairly regular income for the whole State.

(*b*) The same result might be accomplished in another way. Let a nominal annual tax be collected from the owners of timber lands. When the timber is cut collect the tax on the yield and allow a deduction for the previous annual payments with interest to date. If, through a mistake, the annual payments had been excessive, so that, with interest, they exceeded the tax on the yield when finally cut, a rebate would be due the owner. This plan would be necessary only for forests producing an intermittent or irregular yield. Where a sustained annual yield was produced, the tax would simply be collected each year at a certain percentage of the yield. This plan has the advantage of great simplicity. It could be administered either by state or local officers, and the necessary bookkeeping would be very simple.

(*c*) A third way of avoiding the difficulty of irregular local revenue would be to make the forest tax a state tax, pure and simple, compensating the local division in some equitable way, as by a payment from the State according to some definite rule, or by the State surrendering to the local divisions some other source of revenue. Some such arrangement might be introduced by a State which happened to be remodeling its tax system as a whole.

Each of those plans has advantages and difficulties. Probably the second would best fit present conditions in the majority of States. Still other plans might be suggested. At any rate it seems reasonable to believe that no insuperable obstacle to the tax on yield will be found here.

III. THE SMALL WOOD LOT

Another administrative question arises here. To tax every farm wood lot whenever a little timber is removed would be altogether too costly and cumbersome. It might be advisable to tax wood lots having less than a certain area by a somewhat different method. Lots might be classified under some simple rule into a few grades according to quality, the tax per acre being fixed for each grade at a fairly low figure and collected annually, with an additional tax on the yield if the timber were ever entirely cut off.

IV. NECESSARY RESTRICTIONS.

This system of a special timber-land tax must apply to bona fide timber lands only. For example, the laws must be so drawn as to prevent the holding of land without taxation for merely speculative purposes under the guise that it is timber land. It might be advisable to restrict the forest tax to lands not exceeding a certain value per acre, as is done in many of the present exemption laws; or by some provision in the statutes to enforce the actual use of the land for producing timber. It should not be a very difficult matter to provide the proper safeguards against this danger.

V. CUTTING IMMATURE TIMBER.

It may be necessary to make some special provision for the man who, having planted trees, changes his mind and cuts them off before they have grown to any great value. The small tax on the value of the cut might not be a fair compensation for the preceding years of exemption. This situation might be provided for by a simple classification of such lands according to quality and age of trees, with taxation at arbitrary rates for each class.

VI. MATURE TIMBER.

Shall the owner of mature timber be allowed to hold it indefinitely without taxation, or shall he begin to pay taxes as soon as the timber reaches maturity? If it is considered advisable to require some taxes from mature timber which is not cut, some plan must be devised. Here again the object might be accomplished by means of a simple classification of mature-timber land, with a small tax per acre, the regular tax on yield being collected when the timber was finally cut.

VII. TRANSITION PROBLEMS.

Some administrative problems would arise due to the transition from the present to the new system. For example, a mature forest which is cut just after the new plan has gone into effect could not equitably be taxed on its yield, since it has presumably paid its full share of taxation during all the years that the trees have been growing up. Similarly, an equitable compromise would be necessary for timber which was partly grown when the new plan was adopted.

These suggestions regarding practical problems make no pretense to having covered all the possible complications which might arise under special conditions. With regard to all such problems as these, involving special circumstances here and there, but not the general run of ordinary cases, the writer is strongly convinced that the solution should be in the adoption of certain simple, even arbitrary, working rules which aim to secure certainty and ease of administration rather than any nice adherence to theoretical principles.

VIII. EFFECT ON REVENUE.

It may be asked, what will be the effect of the tax on yield upon the revenue of the States and local divisions? Strictly speaking, this question should be answered for each State separately in the light of local conditions. In some cases it is possible that the adoption of the tax on yield might cause some temporary disturbance of the revenue system. In general, it is not believed that this method of taxing timber lands will lead to any serious reduction of revenue. If, as the evidence seems to show, forests are as a rule not excessively taxed to-day, there is no reason to expect any great reduction of revenue through the adoption of the tax on yield. Eventually revenue will be increased by a method of taxation which does not prevent the development of forestry. Forests paying a moderate tax are better than abandoned lands paying no tax at all. This is assuming always that the rate of the forest tax is selected so as to make forests bear the same relative burden as other kinds of wealth. It may be considered advisable to attempt to encourage forestry by a special low rate. In this case some revenue will of course be sacrificed.

IX. CONSTITUTIONALITY.

The plan of a tax on the yield of forests at a special rate, in lieu of the general property tax, will be unconstitutional in many of the States of the United States. These state constitutions stand to-day in the way of many plans for reform in state and local taxation. The movement toward their amendment is growing as part of the general programme of tax reform. If the plan of forest taxation here proposed wins favor, it will simply be an added argument for the speedy amendment of those state constitutions which are now blocking the progress of scientific tax reform.

X. TAXATION OF FORESTS IN EUROPE.

This topic is mentioned here for want of a better place. On account of the limited time for the preparation of this report, it has seemed best to omit a discussion of this subject altogether. Forestry conditions in Europe are so much more advanced than with us that the problem of taxation is less difficult. The prevailing tax systems of European countries are likewise different from ours, the general property tax having been abandoned long ago. In general, European countries base their forest taxation on a combination of ground tax and income tax. The ground tax is based on the average productive power of the forest, estimated in advance from time to time. The income tax is based on the actual income produced.

CHAPTER VIII.

CONCLUSIONS.

It is with a certain feeling of hesitancy that the following conclusions are presented. The time allowed for the preparation of this report has been out of all proportion to the magnitude and importance of the subject. Moreover, the writer expects to make a further thorough study of this subject in the immediate future. The conclusions presented in this preliminary report are therefore somewhat tentative, and it is realized that some of them may possibly have to be modified after further investigation. In the main it is believed that they will prove to be in harmony with the facts.

I. CONTRACT BETWEEN STATE AND FOREST OWNER.

Many schemes of forest taxation have been proposed involving a contract by which the State offers some form of taxation assumed to be particularly favorable to timber lands on condition that the owner agree to plant, cultivate, or maintain his forest according to some specified plan or under the direction of some state authority. This idea has something to be said in its favor; it is also open to some serious objections. At present the writer does not feel prepared to pass judgment upon it. The plan of taxation outlined in this report does not contemplate such a contract. However, there is nothing in the principles here laid down inconsistent with the adoption of such a contract should it be deemed advisable.

II. SPECIAL FAVORS TO FORESTRY THROUGH TAXATION.

Throughout this report we have gone on the assumption that forests should bear the same relative burden of taxation as other kinds of wealth in proportion to income. As has already been shown, however, having once adopted the principle of the tax on yield, it is a simple matter to give any desired favor up to a complete exemption from taxation by merely fixing the rate of the tax. We have, therefore, in no way prejudiced the case against special favors to forestry.

This subject leads us out upon a broader field than the mere problem of correct taxation. Two questions may be asked: (1) Is the proposed encouragement to forestry by a low tax rate a proper use of the taxing power? In general, there would seem to be no reasonable objection to such a policy provided the end sought be an increase of the public welfare and provided the means be effective. Such a programme should, however, be carried out with great caution in order to prevent doing injustice to certain localities. The gain to be obtained from encouraging forestry is to the people in general, and the cost should be borne by those who enjoy the gain, not by the people of the locality where the forests happen to be. If special rates of taxation are granted to forests some arrangement must be made whereby the localities affected will be compensated for the resulting loss of revenue. (2) To what extent will the reduction of taxes prevent the destruction of forests and encourage the practice of forestry? In answering this question we are helped by the evidence presented in preceding chapters of this report. This evidence forces us to the conclusion that in this matter no great relief is to be looked for through the reduction of taxation. It has been shown that taxation has not been the cause of the cutting of our forests, and it is idle to hope that any reduction in taxation will have more than a slight influence in preventing further destruction. Taxation does not explain the present absence of forestry in America, and until other forces have become strong enough to lead to its practice special tax rates will probably not have any great influence.

It may well be that in certain places local conditions are such that great good might be accomplished by a reduced tax on forests. Where this is the case, no objection can be raised to such a programme, provided both general and local interests be safeguarded. But the solution of the general problem of forestry lies mainly outside the realm of taxation.

This matter of a reduced tax rate must of course be distinguished from the question of just and certain taxation. We have already shown that forestry can hardly be expected to flourish until our present tax methods are replaced by a system which insures reasonable equity and certainty. The writer is of the opinion that if a tax at once equitable and dependable is guaranteed, the business of forestry will not need to ask special favors.

III. SOME ADVANTAGES OF THE TAX ON YIELD.

The general advantages of this method of taxing timber lands have already appeared throughout the preceding discussion. It remains here to call attention to certain features which have perhaps not received sufficient emphasis heretofore. In the first place the tax on yield is based upon correct principles. It bears a definite relation to income. Under this method it will be possible to make the tax on forests equitable as between different forest owners and as compared with other kinds of wealth. Still more important, the tax will be certain, a definite part of the yield, which the owner may calculate in advance and depend upon. If fire or accident destroys the yield the tax is reduced accordingly. Being due when the timber is cut, it will be paid at the time most convenient for the taxpayer. Also, being paid when the timber is cut, there will be no inducement to cut timber in order to avoid taxes or to get money with which to pay taxes. There is nothing in the tax to lead to the abandonment of cut-over lands or to prevent reforestation, provided the land can be profitably forested at all. For these and other reasons, the tax on yield, instead of being an obstacle to the practice of forestry, will be a distinct encouragement.

IV. GENERAL SUMMARY AND CONCLUSION.

We have seen that in spite of special statutes in some States timber lands are actually taxed under the general property tax everywhere in the United States. The general property tax is a thoroughly discredited method of taxation. It has proved itself a complete failure, and was abandoned long ago by every [illegible]portant nation except the United States. The general property tax is especially burdensome in the case of forests, because the annual increase in the value of the trees is not taken as income, but is stored up in the forest, there to be taxed over and over again till the timber is finally cut.

In certain parts of the country, and in individual cases almost everywhere, the taxation of timber lands has undoubtedly been excessive and has produced serious results on the forests. As a general rule, however, due to the prevailing habit of under assessment and the lax administration of the law, forests have not been taxed excessively. It also appears that in most cases taxation has not been responsible for the destruction of our forests or for the failure to reforest cut-over lands.

The real problem of forest taxation is in connection with the future of our timber lands rather than with their past. The preservation of the forests is a matter of the utmost importance. So far our forests have been exploited with little or no regard for the future. But the present methods can not last much longer. Forestry must come some time, and its early coming is a thing greatly to be desired. And whenever we are ready to seriously undertake it we will find our present methods of taxation a severe handicap. Strictly enforced, according to the letter of the law, the annual tax on the full value of the land and standing timber is almost sure to result in excessive taxation, and the timber owner can not count on the continuance of the present lenient enforcement of the law. Even if the tax might not be excessive, its uncertainty would be a serious obstacle to investment. We can hardly hope to see the general practice of forestry as long as the present methods of taxation continue.

To be equitable, taxation of timber lands like taxation of anything else should be based on income or earning power. This may be accomplished in the case of forests either by a tax on the yield when cut or by an annual tax on the capital value of the forest, based on all its expected future incomes and expenditures, i. e., on what the foresters call "expectation value." At present and for some time to come the tax on expectation value can not be generally applied to America on account of the slight development of forestry and the absence of the necessary statistical data, such as yield tables, etc. On the other hand, the tax on yield has decided advantages, both theoretical and practical, in its favor. Among others, it does not have to take account of the rate of interest, of the risk of loss by fire, or of future prices of timber.

The tax on the yield when cut is advocated as the principle on which any scientific system of forest taxation should be based. In putting this principle into practice many problems must be met. Suggestions have been made regarding the solution of some of the more important of these. It is not believed that any of these problems will prove incapable of solution.

With regard to its effect on revenue, there is little to be feared from the tax on yield. Eventually, revenue will be increased by a method of taxation which does not prevent the development of forestry. Forests paying a moderate tax are better than waste lands abandoned and paying no tax at all.

Too much confidence should not be placed in the plan to levy a special reduced tax on timber lands in the interest of forestry. It is not likely that a mere reduction of taxation will have any great influence in stopping the destruction of the forests or inducing the practice of forestry.

The tax on yield has many decided advantages. It avoids the evils of the general property tax. It is equitable and certain. It is in harmony with the peculiarities of the business of forestry, and will be a distinct encouragement to the practice of forestry. Its adoption by the States would remove one obstacle to the perpetuation of the nation's forest resources.

REDUCTION OF TIMBER SUPPLY THROUGH ABANDONMENT OR CLEARING OF FOREST LANDS.

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SUMMARY.

The original forested area of the United States, of approximately 900,000,000 acres, has been steadily reduced by the demand for agricultural land and the increasing consumption of lumber and other forest products. The total area of improved farm land in the United States was 118,457,000 acres in 1850; 163,110,000 acres in 1860; 188,921,000 acres in 1870; 284,771,000 acres in 1880; 357,616,000 acres in 1890; 414,485,000 acres in 1900, and approximately 447,762,000 acres in 1907.

Of the total area of improved farms in 1907, not less than 65 per cent, or 292,000,000 acres, has been drawn from the original forests of the country.

The area of timbered land cut over for all forms of forest products was 2,058,000 acres in 1860; 3,468,000 acres in 1870; 4,764,000 acres in 1880; 5,841,000 acres in 1890; 8,577,000 acres in 1900, and 9,429,000 acres in 1907.

The results of the enormous drain from these two sources upon the original forests of the United States are shown by the following figures:

In round numbers, of the virgin forests of the country, in 1907 292,000,000 acres had been put into improved farms and are presumably withdrawn for all time from timber production; 335,000,000 acres, or 37 per cent of the original area, still contain merchantable timber; 180,000,000 acres are completely cut over, but in process of restocking with forest; and 65,000,000 acres, also completely cut over, are not restocking and will not produce a new growth of trees without artificial assistance.

Of the 9,429,000 acres of forest land which were cut over in 1907, 1,049,000 acres were put into farms; 5,642,000 acres are restocking with forest, and 2,737,000 acres are not restocking with forest. Of the total remaining area of merchantable timber, one-thirty-sixth is, therefore, being cut over annually. Of the acreage annually cut over, 11 per cent is put into farms; 60 per cent is restocking with forest and can be counted upon to a greater or less extent for future timber supply, and 29 per cent is not restocking and can be made of future value as timber-producing land only by artificial reforestation.

Estimating the annual growth per acre on all classes and types of forest land in the United States at 72 board feet, the original forests of the country produced annually 64,800,000,000 board feet of timber. The present forested area of the country, after the drain indicated to supply farming lands and various forest products, is producing a little more than 37,000,000,000 feet, or less than 58 per cent of the original production. The withdrawal of lands for agriculture, and methods of logging which leave the cut over areas unproductive of timber, have therefore caused a loss of 25,704,000,000 board feet in the annual wood crop. Of this loss, 21,000,000,000 board feet, is unavoidable, and is due to the necessary increase in the area of farm land; but the remainder of 4,680,000,000 feet is from the areas of cut over land which are not put into farms, but which, because of the methods of logging employed and the lack of protection, are not restocking with forest. This loss should be classed as national waste.

With the farms encroaching upon the forested area at the rate of 1,050,000 acres a year and with the area of cut over land which is not restocking increasing at the rate of 2,737,000 acres a year, the annual loss in timber production is increasing at the rate of 272,664,000 board feet a year. Of this increasing yearly loss of growth 75,600,000 feet may be classed as necessary, because it results from the increased acreage put under tillage; the remainder, or 197,064,000 feet, is unnecessary and can be avoided by improved methods of exploitation and protection.

The significance of this loss in the annual production of timber in the United States lies in its cumulative effect upon future supplies. If the present rate of increase in the areas of forest land which are cleared for tillage and in the areas which are cut over under such conditions that they do not restock with forest is maintained, the loss in growth of timber will amount in ten years to 272,146,000,000 board feet. If farm land is eliminated, the loss resulting from unproductive cut-over lands alone will, in the same period, aggregate 57,638,000,000 board feet. In twenty years the loss from both sources will become 596,452,000,000 board feet, and the loss from unproductive cut-over areas alone 124,144,000,000 board feet.

It is impossible to place exact limits upon the future increase in the acreage of improved farm land because of the many variable factors which enter into this question. The trend of conditions in this respect, however, is indicated by the following figures. One and nine-tenths acres of grain are required to support each person in the United States, exclusive of exports of grain or grain products of any character. In the twenty-seven years from 1881 to 1907, inclusive, the population of the United States increased at the average rate of about 1,290,000 souls a year. During the same period the grain area of the country required for home support alone increased at the rate of 2,400,000 acres annually. If the population continues to increase, not at the same ratio as during the past twenty-seven years, but at the same average number of persons per annum, the ratio of increase steadily diminishing, the country in 1950 will contain 55,470,000 more people than at present. If the same conditions as regards average grain production per acre and average consumption per capita hold true until 1950, the country will require by that year an additional grain area for home consumption only of 82,598,000 acres. The grain area at present forms 41 per cent of the total acreage required for all agricultural products. If this ratio still holds the total increase in improved farm land required for home consumption by 1950 will reach 202,336,000 acres. In this calculation, however, allowance has been made for possible increase in the yield per acre.

In the arid portion of the United States expansion in the acreage of farm land is limited closely by the water supply available for irrigation. The total irrigable area in the West is estimated at 60,000,000 acres. The drainage of morasses would add large areas of highly fertile land. It seems evident that not less than 100,000,000 acres of forest must be withdrawn from timber production by 1950 in order to provide a sufficient food-producing area to make the nation self-supporting.

If the present rate of increase in the cut-over areas which are not reproducing is maintained until 1950, the unproductive cut-over land will in that year amount to 182,000,000 acres. With the further withdrawal of 100,000,000 acres from the timber-growing area required by the demand for agricultural crops, the acreage of forest-producing land of all classes will by 1950 be reduced to 298,000,000 acres or about one-third of its original extent. The original annual growth of timber of 64,800,000,000 board feet will by 1950 be reduced to 21,456,000,000 feet.

Looking toward the distant future it will be of greater value to indicate corresponding conditions in the older and much more thickly settled countries of Europe than to attempt to use the present bases of estimate or comparison. The United States, for example, has a present population of 28.62 persons per square mile, as compared with 191.68 per square mile in France. The United States requires 55.11 acres in grain in each square mile in order to support its population. France requires, or would require if all the grain consumed were grown at home, 176 acres in each square mile. In the United States the annual consumption of grain per capita is 43.85 bushels, while in France it is a little over 21 bushels. If the United States should ever attain a density of population equal to that in France, which in this country would mean a total of 571,000,000 people, and should at the same time bring its average consumption per capita down to the French basis, we would require a grain area of 523,000,000 acres, and a total area in farm crops of 986,000,000 acres.

To make a less extreme comparison, if this country attained a density of population equal to that of Europe as a whole, it would contain 103 persons to the square mile, or a total of 306,000,000. If we increase the average production of grain per acre from its present figure to 29 bushels, the consumption per capita remaining unchanged, 1½ acres of grain would be sufficient to support each person in the United States, or a total grain area of 459,000,000 acres. An approximately equal area would be required for other agricultural products, making the total area under tillage 918,000,000 acres. This would require an addition of 261,000.000 acres of agricultural land to the area estimated for 1950 and would reduce the forest resources of the country to about 219,000,000 acres including the 182,000,000 acres which as has been shown will not restock itself with timber without artificial assistance.

At the same time, if the production per acre could be brought up to the highest level reached in Europe, as in England which produces nearly 11 bushels of grain per acre more than the United States, and if the consumption per capita were reduced to the standard of living now obtaining in Europe, a population of 300,000,000 could be amply supported by the United States with no increase in its present area of improved farm land. The indications are conclusive, however, that such changes will take place very slowly and that as far ahead as can now be foreseen this country must face a steady reduction in its forest area to meet the insistent demand for agricultural land.

The area included in the present boundaries of the United States contained, in its virgin condition, approximately 900,000,000 acres of forest. With the spread of settlement and growth in population, this area has been steadily reduced in order to satisfy two economic wants, viz, the demand for agricultural land and the steadily increasing requisition of lumber and other forest products. The increased acreage of improved farm land from decade to decade from the census of 1850 is indicated in the following table derived from the reports of the census:

TABLE I.—*Area of improved farm land in the United States from 1850 to 1907.*

State.	1850.	1860.	1870.	1880.	1890.	1900.
Alabama	4,435,614	6,385,724	5,062,204	6,375,706	7,698,343	8,654,991
Arizona	...	...	14,585	56,071	104,128	254,521
Arkansas	781,531	1,983,313	1,859,821	3,595,603	5,475,043	6,953,735
California	32,454	2,468,034	6,218,133	10,669,698	12,222,839	11,958,837
Colorado	...	...	95,594	616,169	1,823,520	2,273,968
Connecticut	1,768,178	1,830,807	1,646,752	1,642,188	1,379,419	1,064,525
Delaware	580,862	637,065	698,115	746,958	762,655	754,010
District of Columbia	16,267	12,000	8,266	12,632	9,808	...
Florida	349,049	654,213	736,172	947,640	1,145,693	1,511,653
Georgia	6,378,479	8,062,758	6,831,856	8,204,720	9,582,866	10,615,644
Idaho	...	...	26,603	197,407	606,362	1,413,118
Illinois	5,039,545	13,096,374	19,329,952	26,115,154	25,669,060	27,699,219
Indiana	5,046,543	8,242,183	10,104,279	13,933,738	15,107,482	16,680,358
Iowa	824,682	3,792,792	9,396,467	10,866,541	25,428,899	29,897,552
Kansas	...	405,468	1,971,003	10,739,566	22,303,301	25,040,550
Kentucky	11,368,270	7,644,208	8,103,850	10,731,683	11,818,882	13,741,968
Louisiana	1,590,025	2,707,108	2,045,640	2,739,972	3,774,668	4,666,532
Maine	2,039,596	2,704,133	2,917,793	3,484,908	3,044,666	2,386,889
Maryland	2,797,905	3,002,267	2,914,007	3,342,700	3,412,908	3,516,352
Massachusetts	2,133,436	2,155,512	1,736,221	2,128,311	1,657,024	1,292,132
Michigan	1,929,110	3,476,296	5,096,939	8,296,862	9,865,350	11,799,250
Minnesota	5,035	556,250	2,322,102	7,246,693	11,127,953	18,442,585
Mississippi	3,444,358	5,065,755	4,209,146	5,216,937	6,849,390	7,594,428
Missouri	2,938,425	6,246,871	9,130,615	16,745,031	19,792,313	22,900,043
Montana	...	...	84,674	262,611	915,517	1,736,701
Nebraska	...	...	647,031	5,504,702	15,247,705	18,432,595
Nevada	...	...	92,644	344,423	723,052	572,946
New Hampshire	2,251,488	2,367,034	2,334,487	2,308,112	1,727,387	1,076,879
New Jersey	1,767,991	1,944,441	1,976,474	2,096,297	1,999,117	1,977,042
New Mexico	166,201	...	143,007	237,392	263,106	326,873
New York	12,408,968	14,358,403	15,627,206	17,717,862	16,389,380	15,599,986
North Carolina	5,453,977	6,517,284	5,258,742	6,481,191	7,825,569	8,327,106
North Dakota	...	...	21,322	575,206	4,638,015	9,644,520
Ohio	9,851,493	12,625,394	14,469,133	18,081,091	18,338,824	19,244,472
Oklahoma	...	...	...	...	563,728	8,574,187
Oregon	132,857	896,414	1,116,290	2,198,645	3,516,000	3,328,308
Pennsylvania	8,628,619	10,463,296	11,515,965	13,423,007	13,210,597	13,209,183
Rhode Island	356,487	335,128	289,030	298,486	274,491	180,354
South Carolina	4,072,651	4,572,060	3,010,539	4,132,050	5,255,237	5,775,741
South Dakota	...	...	21,323	575,207	6,969,293	11,285,983
Tennessee	5,175,173	6,795,337	6,843,278	8,496,556	9,362,555	10,245,950
Texas	639,107	2,650,781	2,964,836	12,650,314	20,746,215	19,576,076
Utah	16,333	...	118,755	416,105	548,223	1,032,117
Vermont	2,601,409	2,823,157	3,073,257	3,286,461	2,655,943	2,126,624
Virginia	10,360,135	11,437,821	8,165,040	8,510,113	9,125,545	10,094,805
Washington	...	...	192,016	484,346	1,820,832	3,465,960
West Virignia	...	...	2,580,254	3,792,327	4,554,000	5,498,981
Wisconsin	1,045,499	4,147,420	5,899,343	9,162,528	9,793,931	11,246,972
Wyoming	...	...	338	83,122	476,831	792,332
Territories	...	448,872	...	...	...	...
Total	118,457,622	163,110,720	188,921,099	284,771,042	357,616,755	414,485,553

NOTE.—The figures for 1850 to 1900, inclusive, are taken from the census reports.

Of the total area of improved farms in 1907, not less than 65 per cent has been drawn from land which was originally timbered. In other words, approximately 292,000,000 acres of the original forests of the United States had, prior to 1908, been cleared and devoted to agriculture.

The drain upon the forest areas during the last fifty years to supply the demand for lumber and other forest products is indicated in the two following tables. Table II shows by States the annual cut of lumber, exclusive of other forest products, by decades, from 1860 to 1907. Table III shows the estimated area cut over annually during the same period for all forms of forest products.

TABLE II.—*Cut of lumber in the United States from 1860 to 1907.*

[In thousands of board feet.]

State.	1860.	1870.	1880.	1890.	1900.	1907.
Alabama	156,302	84,943	251,851	596,143	1,096,539	1,224,967
Arizona	....	625	....	....	....	72,134
Arkansas	96,575	84,025	172,503	526,091	1,595,933	1,988,504
California	333,620	336,091	304,795	515,823	734,232	1,345,943
Colorado	....	20,273	63,792	79,906	133,746	134,239
Connecticut	49,121	96,315	64,427	48,277	107,594	140,011
Delaware	23,013	25,315	....	....	....	50,892
District of Columbia	1,760	1,875	....	....	....	....
Florida	123,054	139,746	247,627	411,436	788,905	839,058
Georgia	202,433	252,773	451,788	572,970	1,308,610	853,697
Idaho	....	3,553	18,204	27.800	65,331	513,788
Illinois	223,441	284,173	334,244	218,938	381,584	141,317
Indiana	371,000	770,297	915,943	707,115	977,878	504,790
Iowa	182,100	302,143	412,578	508,816	351,769	144,271
Kansas	130,290	108,524	....	....	....	....
Kentucky	207,985	228,890	305,684	420,820	765,343	912,908
Louisiana	101,003	98,500	133,472	303,591	1,113,423	2,972,119
Maine	597,313	712,234	566,656	564,243	756,515	1,103,808
Maryland	[illegible]	93,842	123,336	81,078	183,393	213,786
Massachusetts	196,096	222,304	205,244	208,655	342,058	364,231
Michigan	608,617	1,996,650	4,172,572	4,245,717	3,012,057	1,827,685
Minnesota	104,800	268,698	563,974	1,079,403	2,341,619	1,660,716
Mississippi	152,685	147,542	168,747	452,797	1,202,334	2,094,485
Missouri	257,085	397,694	399,744	395,755	715,968	548,774
Montana	....	26,935	21,420	89,511	255,685	343,814
Nebraska	27,945	17,398	....	....	....	....
Nevada	....	27,031	....	....	....	....
New Hampshire	107,809	267,884	292,207	266,890	502,258	754,023
New Jersey	135,263	171,582	109,679	32,285	72,660	30,942
New Mexico	3,702	9.827	....	....	....	113,204
New York	883,133	1,327,389	1,184,220	909,990	874,754	848,994
North Carolina	98,001	125,015	241,822	509,436	1,278,399	1,622,387
Ohio	439,990	639,699	910,832	541,076	957,239	529,087
Oklahoma	....	....	....	....	....	140,015
Oregon	57,500	63,388	177,171	444,565	734,181	1,635,563
Pennsylvania	916,172	1,802,436	1,733,844	2,113,267	2,321,284	1,734,729
Rhode Island	6,343	16,079	....	....	....	32,855
South Carolina	93,803	74,813	185,772	197,940	466,109	649,058
South Dakota	....	4,517	....	....	....	34,841
Tennessee	185,709	211,918	302,673	450,097	839,463	894,968
Texas	146,184	122,553	328,968	839,724	1,230,904	2,229,590
Utah	12,125	41,339	....	....	....	14,690
Vermont	77,378	220,320	322,942	370,155	365,869	373,660
Virginia	184,913	131,941	315.939	409,804	956,169	1,412,477
Washington	99,530	81,724	160,176	1,061,560	1,428,205	3,777,606
West Virginia	....	92,300	180,112	299,709	773,583	1,396,979
Wisconsin	384,702	945,670	1,542,021	2,817,200	3,361,943	2,003,279
Wyoming	....	16,750	....	....	....	17,479
All others	....	....	200,317	126,270	226,977	5,891
Total	8,029,318	13,166,212	18,087,356	23,494,853	34,780,513	40,256,154

NOTE.—The figures for 1880 to 1907, inclusive, are taken from the census reports. The census reports for 1860 and 1870 give only the value of lumber cut in the respective States. The best estimates from other sources indicate a total cut in the United States of approximately 8,000,000,000 feet in 1860 and 13,000,000,000 feet in 1870. By comparing these figures with the total value of the lumber cut, as given in the census reports for the same years, an average value per thousand feet of $12 in 1860 and $16 in 1870 is indicated. The value of the cut in each State, as given in the census, was converted into board feet by using these divisors for the respective years.

TABLE III.—*Estimated area cut over annually in the United States from 1860 to 1907, including cordwood and all forms of forest products.*

State.	1860.	1870.	1880.	1890.	1900.	1907.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Alabama	42,201	22,925	67,999	158,263	336,965	531,000
Arizona		108				33,000
Arkansas	26,075	22,686	46,575	142,044	430,902	550,000
California	43,370	42,469	39,623	67,056	95,450	172,300
Colorado		5,473	17,203	21,574	36,111	96,000
Connecticut	13,262	26,005	17,395	13,034	29,050	40,[illegible]
Delaware	6,213	6.835				9,000
District of Columbia	475	506				
Florida	33,224	37,531	66,859	111,067	213,004	340,000
Georgia	54,656	68,248	121,982	154,701	353,324	317,250
Idaho		959	4,915	7,506	17,639	75,000
Illinois	60,328	76,726	90,245	55,123	103,027	25,650
Indiana	100,172	207,980	247,304	190,921	264,027	60,080
Iowa	49,167	97,778	111,496	153,580	94,977	6,300
Kansas	35,178	29,301				2,800
Kentucky	29,155	61,797	82,534	113,621	206,642	428,824
Louisiana	27,270	26,595	36,057	81,909	300,624	500,000
Maine	161,274	192,303	152,997	152,345	204,259	250,000
Maryland	13,703	25,337	33,300	21,891	49,516	87,000
Massachusetts	52,945	60,062	55.415	56,336	92,355	110,000
Michigan	164,326	539,077	1,126,594	1,146,343	813,254	400,000
Minnesota	28,296	72,548	152,273	291,438	362,237	210,000
Mississippi	41,224	39,849	45,561	122,255	324,630	450,000
Missouri	69,412	107,377	107,930	106,853	193,311	165,067
Montana		7,272	5,783	24,167	69,088	99,300
Nebraska	6,845	4,694				1,250
Nevada		7,298				6,300
New Hampshire	29,108	72,328	78,912	72,080	151,809	220,000
New Jersey	36,521	36,326	33,613	8,716	19,618	5,000
New Mexico	1,015	2,663				38,000
New York	238,445	358,395	319,739	245,697	236,183	287,875
North Carolina	26,460	33,754	65,291	137,547	345,167	447,125
North Dakota						1,500
Ohio	118,797	172,718	245,924	146,090	258,454	106,200
Oklahoma						158,240
Oregon	4,197	4,627	12,933	32,453	53,595	120,000
Pennsylvania	247,366	496,657	468,137	570,582	626,746	474,525
Rhode Island	1,712	4,341				3,780
South Carolina	25,326	20,199	50,158	53,445	126,849	168,900
South Dakota		1,219				8,500
Tennessee	50,141	57,217	81,721	121,526	226,708	309,400
Texas	38,469	33,089	88,821	226,725	332,344	600,000
Utah	3,273	11,161				22,200
Vermont	20,892	59,486	87,194	99,841	98,784	100,000
Virginia	49,926	35,624	85,203	110,647	268,165	380,000
Washington	4,578	3,759	7,368	48,832	65,697	172,000
West Virginia		24,947	48,630	80,921	208,967	329,785
Wisconsin	103,869	255,330	406,345	660,644	907,729	492,000
Wyoming		4,522				18,000
All others			54,065	34,092	61,283	
Total	2,068,866	3,468,171	4,764,094	5,841,945	8,577,440	9,429,691

NOTE.—The figures for 1907 are based upon statistics collected by the Forest Service during 1908, by counties and States, for all forested portions of the United States. A comparison of the total area cut over in 1907 with the total lumber cut of that year, the Pacific Coast States excepted in both cases, indicates that for every thousand feet of lumber manufactured a total area of approximately 0.268 acre is cut over for all forms of forest products. By the use of this factor, the annual cut of lumber in each State for the years preceding 1907, as given in the foregoing table, was converted into the area cut over for all forest products. This method is based upon the assumption that the cut of minor forest products has increased proportionately with the cut of lumber. Separate factors were worked out for the States of California, Oregon, and Washington by comparing in each case the cut of 1907 in board feet and in acres. These factors are, respectively, 0.128 for California, 0.073 for Oregon, and 0.046 for Washington.

The totals of the foregoing table show forcibly the steady increase in the drain upon the forest areas of the United States required to supply the consumption of lumber, cord wood, pulp, and other wood products, reaching in 1907 a figure close to 9,500,000 acres.

The next question which presents itself is, Just where do we now stand both as regards remaining areas of merchantable timber and possibilities of future production on areas previously cut over? Table IV gives an estimate of the area in each State which still contains merchantable material, although in several States a considerable percentage of this area has been culled of a portion of the stand, together with those cut-over areas which are restocking with forest and those which are not restocking, respectively.

TABLE IV.—*Areas of merchantable timber, cut-over land which is naturally restocking with forest, and cut-over land which is not restocking.*

State.	Merchantable timber.	Cut-over land restocking.	Cut-over land not restocking.
	Acres.	*Acres.*	*Acres.*
Alabama	8,338,564	11,857,870	1,844,836
Arizona	10,800,000	442,000	590,000
Arkansas	18,000,000	11,416,000	100,000
California	21,600,000	1,960,000	771,800
Colorado	7,900,000	2,100,000	525,000
Connecticut	600,000	1,144,800	10,000
Delaware	154,680	242,160	5,000
Florida	9,000,000	12,058,211	3,014,553
Georgia	11,000,000	12,203,978	1,428,820
Idaho	22,120,000	1,640,000	215,000
Illinois	1,270,653	878,418	193,395
Indiana	1,685,000	3,081,400	400,000
Iowa	131,700	243,400	105,900
Kansas	104,000	24,000	7,000
Kentucky	6,389,540	2,294,475	200,000
Louisiana	9,452,800	6,666,960	1,292,000
Maine	10,682,800	4,500,000	400,000
Maryland	398,230	1,786,326	600,000
Massachusetts	1,972,950	1,000,000	365,382
Michigan	11,000,000	3,000,000	10,687,200
Minnesota	6,000,000	9,055,920	15,093,200
Mississippi	15,000,000	3,985,008	2,656,672
Missouri	7,487,987	9,825,567	1,166,835
Montana	17,000,000	1,445,000	554,000
Nebraska	40,000	14,000	....
Nevada	5,150,000	27,000	104,000
New Hampshire	2,463,066	1,549,347	380,000
New Jersey	500,000	1,049,953	519,819
New Mexico	7,400,000	260,000	78,000
New York	6,007,192	5,907,192	2,262,877
North Carolina	9,379,000	10,114,600	1,950,000
North Dakota	102,600	56,500	14,680
Ohio	2,400,000	2,603,600	670,000
Oklahoma	2,136,000	1,000,000	20,000
Oregon	23,326,480	1,950,000	852,000
Pennsylvania	5,000,000	8,592,480	1,000,000
Rhode Island	155,477	214,376	10,000
South Carolina	3,741,000	7,361,800	1,400,000
South Dakota	1,323,040	84,000	17,700
Tennessee	7,200,000	7,479,690	1,220,000
Texas	11,247,800	3,438,800	3,000,000
Utah	6,700,000	650,000	480,000
Vermont	2,000,000	1,708,736	....
Virginia	5,783,200	7,713,480	1,471,800
Washington	15,740,000	2,900,000	516,000
West Virginia	3,900,000	3,689,040	1,400,000
Wisconsin	5,600,000	8,663,840	5,500,000
Wyoming	9,540,000	126,300	22,200
Total	334,923,759	180,006,217	65,046,669

NOTE.—This table is compiled from reports by county clerks during the summer of 1908. The totals for several States as thus obtained are undoubtedly incorrect, and are presented simply as a basis for discussion.

It appears, therefore, that of the originally forested area of the United States 292,000,000 acres have been put into improved farms and are presumably withdrawn for all time from timber production; approximately 335,000,000 acres, or about 37 per cent of the original area, still contain merchantable timber; 180,000,000 acres are completely cut over but restocking with forest; and a little more than 65,000,000 acres, also completely cut over, are not restocking and will not produce a new growth of trees without artificial assistance.

The United States is cutting annually approximately 9,500,000 acres, or about one thirty-sixth of its total area, of merchantable timber. Of the acreage annually cut over, it is estimated that 11 per cent, or 1,050,000 acres, is put into farms; that 60 per cent, or 5,642,000 acres, is restocking with forest and can be counted upon, to a greater or less extent, for future timber supply; and that 29 per cent, or 2,737,000 acres, is not restocking and can be made of future value as timber-producing land only by artificial reforestation.

The annual growth of wood on all classes and types of forest land in the United States, including cut-over areas which are restocking, is estimated at 12 cubic feet, or 72 board feet, per acre. On this basis the original forests of the country, covering 900,000,000 acres, produced annually 64,800,000,000 board feet of timber, or enough to supply fully the annual consumption of lumber, cord wood, and every kind of forest product up to within the last ten years. On the same basis the annual growth of wood on the present forested area of the United States of 515,000,000 acres, including land bearing merchantable timber and cut-over areas which are restocking, is a little more than 37,000,000,000 feet, less than 58 per cent of the original production. Regardless, therefore, of the actual amount of timber which has been cut from year to year, the clearing of forest acres for agriculture and methods of logging which leave the cut-over land in such condition that natural reproduction is not possible have caused a loss of 25,704,000,000 board feet in the annual wood crop of the country. Of this amount a little over 21,000,000,000 feet is an unavoidable loss, resulting from the necessary increase in the area of farm land. There is, however, a present annual loss in the wood crop of the country of 4,680,000,000 board feet on the area of cut-over land which is not put into farms but which, because of the methods of logging employed and the lack of protection, is not restocking with forest. It has been shown, furthermore, that the farms are encroaching upon the forested areas at the rate of 1,050,000 acres a year and that the area of cut-over land which is not reforesting is increasing at the rate of 2,737,000 acres a year. In other words, the annual loss in growth resulting from the withdrawal of areas from timber production is increasing at the rate of 272,664,000 board feet a year. Of this increase in the yearly loss of growth, 75,600,000 feet may be classed as necessary, because it results from the increased acreage put under tillage; a loss of 197,064,000 feet, arising from the cut-over lands which are not put to any economic use and at the same time are not restocking with forest, should be classed as unnecessary, or national waste.

The significance of this steady decrease in the growing stock of the country lies in its cumulative effect upon future timber supplies. The loss in growth of timber on the areas which have been and are being withdrawn from forest production, either as farm land or as nonrestocking cut-over land, if the present rate of increase is maintained, will amount in ten years to 272,146,520,000 board feet. If the element of farm land is eliminated, the loss resulting from the unproductive cut-over lands alone will, in the same period, aggregate 57,638,520,000 board feet. In twenty years the loss from both sources will become 596,452,920,000 board feet, and from the unproductive cut-over lands alone 124,144,920,000 board feet.

The greatest and most permanent factor in reducing the annual growth and future supply of timber in the United States has been the necessary clearing of forest-producing lands for cultivation. It is therefore pertinent to inquire what limits, if any, can be placed upon the increase in improved farm land and the proportionate decrease in forest-producing land. So many factors enter into this question—the future increase in population, the extent of agricultural exports in the future, the probable increase in the average production per acre, the probable decrease in the consumption per capita—that there is little reliable basis for even approximate estimates. It will be attempted simply to indicate the present trend as to the increase in the crop-producing area and to suggest its future limits if certain broad assumptions are accepted.

Table V has been prepared to furnish a basis of comparison between the increase in population in the United States from decade to decade and the accompanying increase in the acreage, production, and home consumption of the staple grains.

TABLE V.—*The population of the United States, by decades, compared with the acreage, yield, and home consumption of the staple grains—wheat, corn, oats, rye, barley, buckwheat.*

Year.	Total crop.	Exports.	Home consumption.	Area required for total crop.	Area required for home consumption.	Population.
	Bushels.	*Bushels.*	*Bushels.*	*Acres.*	*Acres.*	
1850	867,453,967	....	....	40,191,738	....	23,191,876
1860	1,239,039,947	....	....	59,838,074	....	31,443,321
1870	1,387,299,153	....	....	69,254,016	....	38,558,371
1880	2,718,193,501	407,634,224	2,310,559,277	120,926,286	98,653,642	50,155,783
1890	2,518,261,647	285,308,568	2,232,953,079	140,611,020	122,340,680	62,622,250
1900	3,528,946,736	675,662,050	2,853,284,686	158,304,626	121,317,441	76,085,794
1907	4,180,303,000	454,622,632	3,727,680,368	186,153,000	163,718,365	85,000,000

NOTE.—The crop, export, consumption, and acreage statistics in this table were compiled from the following publications of the Department of Agriculture: Agricultural Statistics, 1907 (reprinted from "Yearbook of Department of Agriculture for 1907"); Bulletin No. 55, Meat Supply and Surplus; Bulletin No. 34, Agricultural Exports of the United States, 1851–1902.

The population for the years 1850 to 1900, inclusive, is taken from the census reports. The population for 1907 is estimated.

The exports include flour, oatmeal, corn meal, bran, and middlings, and the estimated amount of grain consumed in producing the meat and meat products which are exported. This was arrived at as follows: The total exports of meat and meat products, live animals being reduced to dressed weight, were approximately 1,474,000,000 pounds in 1880, 1,612,600,000 pounds in 1890, 2,433,035,000 pounds in 1900, and 2,244,422,580 pounds in 1907. The ratio of 1 bushel of corn per each 11 pounds of meat was applied to these figures and the results included in the total grain exports of the respective years.

The exports do not include breadstuffs and other manufactured articles, since exports of this character are largely offset by imports.

The area required for home consumption was determined by dividing the amount of each kind of grain consumed in the United States in each of the respective years by the average yield per acre for that year.

From the foregoing table it will be noted that in the twenty-seven years from 1881 to 1907, inclusive, the grain area of the United States required to support the home population, wholly exclusive of exports, increased at the rate of approximately 2,400,000 acres annually. During the same period the population of the country increased at the rate of almost 1,290,000 souls a year. In other words, 1.9 acres of grain are required to support each person in the United States and the grain area of the country must be increased by that amount for each person added to our population. If we assume that the population continues to increase, not at the same ratio as during the past twenty-seven years but at the same average number of persons per annum, a far more conservative estimate, the country in 1950 will contain 55,470,000 more people than at present. If we assume, further, that the same conditions as regards average grain production per acre and average consumption per capita which have obtained during the last twenty-seven years will hold true until 1950, the country will require by that year an additional grain area for home consumption only of 82,958,000 acres. The grain area, however, forms but 41 per cent of the total acreage required for all agricultural products. If this ratio still holds, the total increase in improved farm land required for home consumption only by 1950 will reach 202,336,000 acres.

Outside of the areas of the United States, which were originally forested and which are coincident with the regions of abundant rains, expansion in the acreage of farm land is limited by water supply available for irrigation and by the areas susceptible of dry farming. The Reclamation Service estimates the total irrigable area in the West at 60,000,000 acres. No exact limits can be placed upon the area which sooner or later will be brought under tillage through the development of dry farming. It is probable, however, in view of the customary, if not essential, practice of fallowing the land in alternate years, that the crop-producing area added in any one year under dry farming will not exceed 40,000,000 acres. After making these allowances to cover the land which may be brought into cultivation outside of the forested regions, it is evident, under the assumptions above stated, that not less than 100,000,000 acres of forest must be withdrawn from timber production by 1950 in order to provide a sufficient food producing area to make the nation self-supporting.

It has been shown that of the original forested area in the United States 65,000,000 acres are completely cut over and are not restocking with timber and that this area is increasing annually at the rate of 2,737,000 acres. If this rate of increase is maintained until 1950, the unproductive cut-over land will in that year amount to 182,000,000 acres. With the further withdrawal of 100,000,000 acres from the timber-growing area required by the demand for agricultural crops, the acreage of forest-producing land of all classes will by 1950 be reduced to 298,000,000 acres, or about one-third of its original extent.

In any attempt to forecast conditions, the present bases of estimate or comparison are untrustworthy. It will be of greater value simply to indicate corresponding conditions in the older and much more thickly settled countries of Europe. Table VI shows the essential statistics of population, grain area, yield, and consumption in the United States compared with several European countries.

TABLE VI.—*Density of population, area in grain per square mile, average yield, and per capita consumption in the United States, compared with the most densely populated countries of Europe.*

Country.	Population per square mile.	Acres in grain per square mile.	Acres in grain per square mile required for home consumption.	Average yield per acre.	Annual consumption per capita.
				Bushels.	*Bushels.*
United States	28.62	62.68	55.12	22.45	43.85
France	191.65	163.20	176.00	23.27	21.02
Germany	290.56	174.08	208.64	31.94	23.71
Italy	303.73	184.96	206.72	14.82	10.09
Denmark	171.56	194.56	264.32	31.04	47.83
United Kingdom	349.91	65.28	183.68	32.92	17.25

NOTE.—The statistics for the United States are for the year 1907 and compiled from Table V. The statistics for the European countries are for the year 1905 and compiled from Bulletin 68 of the Department of Agriculture, entitled "Cereal Production of Europe." The grain area per square mile required for home consumption includes net imports, reduced to an acreage basis by dividing the imports of each kind of grain by the average yield per acre of the same grain in the respective countries. In the average yield per acre the net imports, reduced to an acreage basis as above, are included, the aim being to show as closely as possible the grain area required if each country were self-supporting. In the European statistics, exports and imports of meat or manufactured food products are not considered. Maslin, spelt, millet, and einkorn are included in the statistics for the countries where these grains are grown.

If the United States, for example, should ever attain a density of population equal to that in France, which in this country would mean a total of 571,000,000 souls, and should at the same time bring its average consumption per capita down to the French basis, we would require a grain area of 523,000,000 acres. In France, grain forms 53 per cent of the total area under cultivation. On that basis we would require, therefore, a total area in farms of 986,000,000 acres.

If the density of population became as great as in Germany, Italy, Denmark, or the United Kingdom, as indicated in the foregoing table, a still greater area under tillage would be required.

To make a second and less extreme comparison: Europe as a whole, with its seacoast, forested mountains, and great interior steppes, corresponds in a general way with the physiographic conditions in the United States. If this country attained a density of population equal to that of Europe as a whole, it would contain 103 persons to the square mile, or a total of 306,000,000.

Let us assume, further, that the average production of grain per acre is increased meanwhile from its present figure of 22.45 bushels to 29 bushels and that the consumption per capita remains unchanged. One and a half acres of grain would then be required for each person in the United States, or a total grain area of 459,000,000 acres. An approximately equal area would be required for other agricultural products, making the total area under tillage 918,000,000 acres. On the other hand, the preceding table indicates very clearly that if the production per acre were brought up to the highest level reached in Europe—namely, in Germany or the United Kingdom—and the consumption per capita reduced to the figures which now obtain in any of the European countries specified, except Denmark, a population of 300,000,000 could be amply supported by the United States with no increase in its present area of improved farm land. The indications are conclusive, however, that such changes will take place very slowly, and that as far ahead as can now be foreseen this country must face a steady reduction in its forest area to meet the insistent demand for agricultural land.

UTILIZATION OF WOOD WASTE BY CHEMICAL AND OTHER MEANS.

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The term "wood waste" as employed in this article includes discarded or unutilized wood or wood products which are depreciating in value through natural processes of decay, etc., which are being destroyed in order to get them out of the way, or which are simply unrecovered by-products.

CLASSIFICATION AND POSSIBLE USES OF WASTE.

Wood waste may be classified under three heads: (1) Natural waste, (2) primary waste, and (3) secondary waste.

Under (1) may be placed that waste which occurs as the result of the natural death and decay of mature, uncut trees. Such waste may consist of species of little value for which no extensive uses have been found, or valuable species which for various reasons can not be profitably handled.

Under (2) may be classified those materials which are discarded in the process of manufacture but still remain wood in some form, even though greatly altered mechanically. Such a waste includes that portion of the tree discarded in logging and sawmill operations, building and workshop refuse, etc., and may be further subdivided according to the particular form in which it occurs, as tops, stumps, butts, cull logs, slabs, edgings and trimmings bark, sawdust, shavings, etc.

Under (3) may be classified all forms of waste wood products which occur as a result of complete chemical alteration of the wood or which are by-products of ordinary methods of treating lumber; as sulphite liquor from pulp mills, pyroligneous acid from southern pine distillation, and turpentine from dry kilns.

In any young country richly endowed with forest lands wastes of the above nature invariably appear. As a rule the trees are cut for some special purpose, such as lumber, and it is impossible to utilize every portion of the tree in the production of this particular material. Until profitable uses are found for all parts, these wastes are bound to occur and are, to a certain extent, excusable. When, however, profitable methods for the utilization of these discarded portions are discovered, or when improvements in the methods of cutting and sawing make it possible to avoid much of the waste, it is criminal not to put such methods and improvements into operation.

As the civilization of a country progresses, its people develop new requirements and demand new and more expensive ways of gratifying them. In this manner new forms of wastes are often developed, although the new requirements may be to a certain extent satisfied by former waste materials.

The extent to which a country utilizes its waste may, in a sense, be taken as a measure of its development, and all the various factors which enter into the development of that country have an intimate bearing on the subject. Such utilization invariably starts locally, but, as progress is made, it takes on more and more national proportions. It is stimulated by many things, the most important of which are competition and the depletion of natural resources.

So long as the demand for the chief products of any industry exceeds the production, and profits are good, little thought is given to by-products. When, however, the industries have become thoroughly established, and competition in its various phases has become so great that the profits are reduced to a minimum, the eyes of the industrial firms are opened to the necessity of practicing the greatest possible economy. As competition of this nature increases, cheaper raw material and cheaper methods of production are provided, if possible; but it is generally the case that profits are more and more derived from the utilization of former waste materials.

Depletion of natural resources curtails production, forcing the people to seek substitutes, and very often waste materials are resorted to as substitutes for the chief products of the industry in which these wastes occur. For example, in many European countries where the forest resources have been greatly reduced, substitutes for lumber are commonly made from sawdust, a waste from the lumber industry.

Nor are competition and depleted resources the only factors which stimulate such forms of economy. With the country's development the desires and necessities of the people increase, and the number of commercial products increases, thus enlarging the opportunity for making substitutes. Such changes are bound to result in finding uses for new products and new uses for old ones. Then, too, the actual ability of the people to handle perplexing problems in a new country is only perfected gradually. The development of no two countries has ever been exactly the same, and the people very often have to be educated by experience to the point where they can solve their own particular problems, although a knowledge of the similar experience of other nations is generally of value.

Now, let us look at the other side of the subject:

There are many things which tend to retard waste utilization, even when there is a most pressing need for it. Among these may be mentioned:

1. Lack of demand for the products which may be obtained, or unfavorable economic conditions which make their production too costly.

2. Ignorance of the methods employed in other countries in which similar problems have arisen and of those employed in allied industries.

3. Prejudice in favor of a staple article which has long been used for a specific purpose, even though a new article may answer the

purpose as well as or even better than the old one, and lack of business organization to overcome this prejudice.

The advantages to be derived from utilizing waste are ordinarily looked upon by the individual from a standpoint of immediate gain to himself; the ultimate result, however, of such utilization is usually to increase not only the individual wealth by the amount of profit, but also the total wealth of the whole country by an even greater amount. And, further, unless the utilization of waste is put into effect as soon as it is found to be practicable, future development will be retarded by depleted natural resources.

The United States has now reached that stage in its development where it is face to face with a timber famine. The demands of the people are great, and the competition of the great industrial concerns to obtain control of natural resources (a most serious form of competition) is very keen. Such a condition of affairs should stimulate the large industries to adopt the far-sighted policy of practicing the strictest economy in the utilization of the raw materials under their control, but, strange to say, until recently very little attention has been given to the subject of the utilization of wood waste, and at present there seems to be a general lack of knowledge of the methods to be employed or the results to be obtained.

NATURAL WASTE.

It is impossible to obtain a close estimate of the annual amount of natural waste, and it will therefore be treated only in general. The waste which comes under this heading may be classified as follows: (1) Accessible timber which does not have a sufficiently high value for lumber to pay for extensive cutting; (2) timber which occurs in inaccessible localities; and (3), valuable decaying timber on lands held for future logging operations. The natural waste from only the first class might, however, be checked by new methods of utilization, and this class only will be discussed here.

Scrub pine in the East, and white fir, Engelmann spruce, lodgepole pine, and lowland fir in the West, are the principal species of this class. None of these trees has a high value for lumber, and the only one which was cut in sufficient quantity to be mentioned in the census report for 1907 was the white fir. The estimated stand of white fir in Oregon and California alone is 3,200,000,000 board feet, and considerable amounts also occur in northern Arizona and New Mexico. No estimates of the total amounts of standing Engelmann spruce are available, but over 1,500,000,000 board feet have been reported as occurring on four national forests. Scrub pine is said to form about 20 per cent of the wooded area of Maryland and 10 per cent of the wooded area of Virginia. The supply of lodgepole pine and lowland fir is also very large. None of these species are at the present time used to any appreciable extent and in some cases they greatly hinder the growth of more desirable woods.

A method for the utilization of this timber in such quantities as to make extensive cutting practicable would be of assistance in preventing much of the natural waste. Recent work of the Forest Service has shown that all of the species mentioned can be made into a commercial quality of paper pulp by the ordinary sulphite process.

The white fir and Engelmann spruce give especially good pulp, the product obtained from the former being even superior in some respects to that from the standard pulp wood—eastern spruce. In view of the facts that the price of pulp wood is steadily advancing and the demand for pulp and paper products is increasing, the possibility of utilizing this timber is very encouraging.

Another method which offers great possibilities in the prevention of natural waste by the utilization of certain species, which on account of their poor lasting qualities do not now possess a high commercial value—the method of preservative treatment—is discussed by another writer.

PRIMARY WASTE.

Species.	(1) Lumber produced in 1907.[a]	(2) Equivalent wood volume.[b]	(3) Total volume of logs.[c]	(4) Slabs, trimmings, and edgings.[d]
	Board feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
Total	40,256,154,000	3,355,000,000	6,580,000,000	1,445,000,000
Yellow pine	13,215,185,000	1,101,000,000	2,160,000,000	475,000,000
Douglas fir	4,748,872,000	397,000,000	780,000,000	171,000,000
White pine	4,192,708,000	349,000,000	684,000,000	150,000,000
Oak	3,718,760,000	310,000,000	608,000,000	134,000,000
Hemlock	3,373,016,000	281,000,000	551,000,000	122,000,000
Spruce	1,726,797,000	144,000,000	282,000,000	62,000,000
Western pine	1,527,195,000	127,000,000	249,000,000	55,000,000
Maple	939,073,000	78,000,000	153,000,000	34,000,000
Poplar	862,849,000	72,000,000	140,000,000	31,000,000
Cypress	757,639,000	66,000,000	130,000,000	29,000,000
Chestnut	653,239,000	56,000,000	110,000,000	24,000,000
Beech	430,605,000	36,000,000	70,000,000	15,000,000
Birch	387,614,000	32,000,000	62,000,000	14,000,000
Basswood	381,088,000	32,000,000	62,000,000	14,000,000
Cottonwood	293,161,000	23,000,000	45,000,000	10,000,000
All others	3,048,853,000	254,000,000	498,000,000	114,000,000

Species.	(5) Absolute waste in trimmings and edgings.[e]	(6) Sawdust.[f]	(7) Absolute waste in sawdust.[g]	(8) Bark.[h]	(9) Tops, stumps and cull logs.[i]
	Cubic feet.	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*	*Cubic feet.*
Total	450,000,000	920,000,000	92,000,000	854,000,000	1,640,000,000
Yellow pine	147,000,000	303,000,000	30,000,000	281,000,000	540,000,000
Douglas fir	53,000,000	109,000,000	11,000,000	101,000,000	195,000,000
White pine	47,000,000	96,000,000	10,000,000	89,000,000	171,000,000
Oak	42,000,000	85,000,000	9,000,000	79,000,000	152,000,000
Hemlock	38,000,000	77,000,000	8,000,000	72,000,000	138,000,000
Spruce	19,000,000	40,000,000	4,000,000	37,000,000	70,000,000
Western pine	17,000,000	35,000,000	4,000,000	32,000,000	62,000,000
Maple	10,000,000	21,000,000	2,000,000	20,000,000	38,000,000
Poplar	10,000,000	20,000,000	2,000,000	18,000,000	35,000,000
Cypress	9,000,000,	18,000,000	2,000,000	17,000,000	32,000,000
Chestnut	8,000,000	15,000,000	2,000,000	14,000,000	27,000,000
Beech	5,000,000	10,000,000	1,000,000	9,000,000	17,000,000
Birch	4,000,000	9,000,000	1,000,000	8,000,000	15,000,000
Basswood	4,000,000	9,000,000	1,000,000	8,000,000	16,000,000
Cottonwood	3,000,000	6,000,000	1,000,000	6,000,000	11,000,000
All others	34,000,000	70,000,000	7,000,000	65,000,000	125,000,000

[a] Census reports for 1907.

[b] Obtained from the figures in column 1 by dividing by 12,000.

[c] Obtained from the figures in column 2 by dividing by 0.51.

[d] Obtained from the figures in column 3 by multiplying by 0.22.

[e] Obtained from the figures in column 4 by multiplying by 0.31.

[f] Obtained from the figures in column 3 by multiplying by 0.14.

[g] Obtained from the figures in column 6 by multiplying by 0.10.

[h] Obtained from the figures in column 3 by multiplying by 0.13.

[i] Obtained from the figures in column 3 by dividing by 4, the estimated ratio of tops to logs being 1:4.

This table was prepared largely from the estimates of Mr. Margolin on milling wastes in which the slabs, trimmings, edgings, etc., were given as 22 per cent, sawdust as 14 per cent, and bark as 13 per cent of the total log; the woods waste, including tops, stumps, and cull logs, was estimated as 20 per cent of the total tree. In making computations for the table, the above percentages, which are to be considered as averages for all species, were applied to each species separately, but the figures obtained are for all practical purposes sufficiently close to the actual total production of these by-products.

In collecting statistics, estimates were also obtained for the proportion of some of these products absolutely wasted. The reports from all the mills answering inquiries showed a total production of 1,873,246 cords of slabs, trimmings, edgings, etc., of which 469,511 cords, or 25 per cent, were burned for fuel at the mills; 822,526 cords, or 44 per cent, were sold as fuel, and the remainder, 581,209 cords, or 31 per cent, were burned in the refuse burners. By using 31 per cent as the absolute waste and applying this percentage to the figures for the total production of slabs given in column 4 the estimates of the absolute waste in slabs by species, given in column 5, is obtained. The absolute waste in sawdust is estimated from the same reports as about 10 per cent of the total production, about 90 per cent being used for fuel at the sawmill. Applying this 10 per cent to column 6 the absolute waste is obtained in column 7. No part of the bark is especially utilized as such except in a few species, although some of it is used as fuel in the form of sawdust or attached to the slabs. The woods waste shown in column 9 can be considered as all absolute waste, except in the case of very few species.

The possible uses for these wastes will be discussed according to special uses applicable only to certain species or groups of species, and general uses applicable to all species.

SPECIAL USES.

All woods containing turpentine in sufficient quantities can be utilized for the production of this material by the process of steam distillation. Reports indicate that southern yellow pine is the only timber whose sawmill waste could be utilized economically by this method under present conditions, although the wastes from Douglas fir and western yellow pine contain enough turpentine, so that it may some time be profitable to utilize them in this manner. The process consists, in brief, of treating the wood (chipped or "hogged" into small pieces, if not already in a state of fine division like sawdust) in a closed steel retort with steam under some pressure, and condensing the escaping vapors which consist of steam and the volatile oils from the wood. By this process the wood fiber is not injured, and the steamed chips can be used for fuel as well as before extraction. For this reason not only the absolute waste as given in columns 5 and 7 but also the amount of wastes burned as fuel at the mills, can be utilized in this manner. According to the estimates, 25 per cent of the slabs and edgings are used as fuel at the mill, and this added to the absolute waste, 31 per cent, will give the amount of slabs which could be treated by this process, 56 per cent, or, in the case of yellow pine, 266,000,000 cubic feet, or 3,325,000 cords. Practically all sawdust is either burned in the fire box or the refuse burner, or allowed to accumulate in the waste pile, the amount which finds other application being negligible. The total production of sawdust from yellow pine, 303,000,000 cubic feet, or 4,600,000 cords (70 cubic feet per cord) could, therefore, be utilized by steam distillation. There are also 540,000,000 cubic feet, or 6,000,000 cords of tops, stumps, etc., from this timber, making a total of 14,600,000 cords of waste wood which could be used for the production of turpentine. The average yield of turpentine from this material would be about 2.5 gallons per cord, giving 36,500,000 gallons of steam-distilled wood turpentine, an amount greater by 6,000,000 gallons than the total production of gum turpentine in 1905. Even at the extremely low price now current for this article, 30 cents per gallon, this would mean a product with a value of $10,950,000. On computing in the same way the waste from Douglas fir and western pine which might be utilized by this process, 5,200,000 cords of the former, and 1,660,000 cords of the latter are obtained. The average yields of turpentine from this material would be for Douglas fir about one-third gallon per cord and for western pine about three-fourths gallon per cord, giving a total of 3,000,000 gallons from these two woods.

The large-sized mill and logging wastes, such as slabs, tops, and stumps, from the three species mentioned could also be used by the process of destructive distillation for the production of turpentine, tar, tar oils, and charcoal, but such a method is more especially adapted to very resinous wood, such as old stumps and "light wood," and would probably not be profitable on the average mill and logging wastes unless the most resinous portions of these materials were selected. On account of the lack of estimates on the quantity of such material available, this process will not be discussed further.

Beech, birch, and maple were used by destructive distillation for the production of wood alcohol, acetate of lime, and charcoal to the extent of 1,220,000 cords in this country in 1907. Most of the wood is cut especially for this purpose, although the use of about 60,000 cords of sawmill slabs was reported in 1907. No practicable method has yet been found for the destructive distillation of small stuff, such as shavings and sawdust; so that only large-sized waste, such as slabs, ends, tops, and limbs, could be utilized by this method. The absolute waste in slabs, trimmings, tops, stumps, etc., from beech, birth, and maple, as given in the table, amounts to 1,115,000 cords (89,000,000 cubic feet), or over 90 per cent, of the amount of hard wood used for distillation in 1907. If this waste beech, birch, and maple had been utilized, products with a value of nearly $7,000,000 would have been obtained.

Oak wood is used to some slight extent in this industry, but only when mixed with beech, birch, and maple. Oak yields on distillation, in comparison with these woods, fully as much charcoal, nearly as much acetate of lime, and about one-half as much wood alcohol. There were wasted in 1907, 2,400,000 cords of oak wood, which, if distilled, would have produced very nearly twice as much charcoal and acetate of lime, and very nearly as much wood alcohol, as was produced in hard-wood distillation plants in this country during that year.

Hemlock, spruce, poplar, and cottonwood are at present being used in large quantities commercially as a raw material for paper making. Douglas fir, basswood, chestnut, and the various species of pine are used to a considerably smaller extent, but still can be and are successfully used for certain grades of paper.

It can be safely stated that almost any species of wood can be made into some grade of pulp, and that practically all species can be made to produce a pulp which is commercially acceptable. The economic utilization of waste wood is, however, a subject presenting some difficulties and requiring careful study. Waste wood is not in general the clear, clean wood to which pulp mills are accustomed, and often much trouble is experienced in preparing it for the digester; the knots, bark, rotten wood, and dirt must in many cases be removed, and the excessive handling in the preliminary treatment preceding the cooking process is often expensive. Waste wood of some species is, however, already being used with success (160,000 cords of slabs in 1907), especially where the pulp mills are located near sawmills. This method of utilization is therefore capable of great expansion. The utilizing of sawdust by this process has been little investigated up to the present time, but, according to some authorities, has possibilities. No final solution can at present be offered, however, and sawdust will therefore be left out of account in considering wastes that may be utilized for paper making.

If the slabs, ends, etc., which were absolute waste, and all the tops, limbs, etc., from the hemlock, spruce, poplar, and cottonwood cut for lumber in 1907 had been used for paper making, there would have been available, according to the table, 4,050,000 cords, or slightly more than the quantity of wood actually used for paper making in this country in that year. The use of yellow pine, Douglas fir, and western pine waste as mentioned does not prevent the use of the same material afterwards for paper making, since the wood fiber is not injured by the steam distillation. The only species which need be left out of the grand total which could be utilized for pulp are, therefore, beech, birch, maple, and oak, which have been considered as already utilized by destructive distillation. The total absolute waste in slabs is 450,000,000 cubic feet, or 5,600,000 cords, and in tops, stumps, etc., is 1,640,000,000 cubic feet, or 20,500,000 cords, giving a total waste of 26,100,000 cords. This amount minus 3,515,000 cords, the material already considered as utilized, leaves 22,600,000 cords, or five and one-half times as much wood as is annually used by the paper-pulp industry.

The only special use which has ever been found for large quantities of the bark of any species is as a source of tanning material. Hemlock and oak are the only barks which are now utilized for this purpose to a large extent, about 900,000 cords of the former and 380,000 cords of the latter being consumed in 1907. The total amount of hemlock bark produced as a result of the lumber cut in 1907 was, according to the table, 72,000,000 cubic feet, or about 900,000 cords, nearly all of which was utilized, since probably very little bark was cut without also using the lumber. The 380,000 cords of oak bark used in 1907 came mostly from the chestnut oak and the tanbark oak, since the bark from these species contains more tannin than from other oak. The total amount of bark from all species of oak cut for lumber in 1907 was 78,000,000 cubic feet, or about 970,000 cords, showing that about 590,000 cords of oak bark were unutilized. Oak wood also contains a small amount of tannin, but it is apparently not profitable at the present time to utilize this material or the bark from other oaks than tanbark and chestnut oak. In the year 1907 about 135,000,000 pounds of tanning extract from chestnut wood were used. If the absolute waste from chestnut, including all the sawdust, had been used in making tanning extract, 50,000,000 cubic feet, or 625,000 cords, of wood would have been available. At the rate of 500 pounds of extract per cord of wood this waste material would have yielded 312,500,000 pounds of extract, or more than twice as much as was used in this country in 1907. This does not indicate that half of this waste was actually utilized, because a considerable part of the extract was probably made from wood cut especially for this purpose. The use of chestnut wood for extract does not prevent the further utilization of the extracted chips for paper making, or of extracted sawdust for fuel. Other barks which contain tannin, which may be but are not utilized for production of tanning materials, are chestnut, willow, beech, birch, poplar, and spruce. Tanning materials worth $3,936,000 were imported into this country in 1907, which might have been replaced to some extent by domestic products manufactured from waste materials.

The possible profitable utilization of the leaves of conifers is apparently the last thing in the line of by-products to be thought of, and yet several years ago it was announced that the leaves of the eastern hemlock contained about 1 per cent of an oil which was composed of over 50 per cent borneol acetate, a substance which can be transformed into camphor by quite simple methods. More recently similar studies have been made on the leaves of the red cedar and Douglas fir of the Western States, with the result that volatile oils of possible commercial value have been obtained. There is a large field for investigation here, since the composition of the leaf oils of very few conifers is now known.

GENERAL USES.

In the above list of special uses there were mentioned possible methods for the utilization of all the large-sized waste, except the bark from those species which do not contain tannin in sufficient quantity to make its extraction profitable. No methods were suggested, however, for the complete utilization of the sawdust. The steam distillation of yellow pine sawdust, or the leaching of chestnut sawdust, still leaves the main woody material for further treatment. Under "General uses" will be mentioned in three divisions—(1) chemical, (2) mechanical, and (3) fuel and power—methods which are applicable to all species alike, and to sawdust as well as or even better than to larger sized material.

(1) Under general chemical methods of utilizing sawdust may be mentioned the production of oxalic acid by treating sawdust with fused caustic alkali, and the production of ethyl or grain alcohol by treating sawdust with dilute sulphuric acid and fermenting the sugar so formed. Practically no oxalic acid is manufactured in this country at present, and 7,900,000 pounds were imported in 1905.

This process is not of much interest, however, as a method of utilizing waste sawdust, because 8,000 tons of sawdust, or only about 0.05 per cent of the total sawdust produced in this country in 1907, would make as much oxalic acid as was imported in 1905.

It is well known that ethyl or grain alcohol can be produced from wood by the general method of hydrolysis by acids with subsequent fermentation of the sugar so formed, and processes for the commercial utilization of waste wood in this manner have often been suggested. One of these processes was tried in this country a few years ago, but resulted in a failure, apparently because of difficulties in the mechanical manipulations rather than in the control of the fundamental chemical reactions. A special modification of the general method is said to be in successful operation in France, and new modifications have lately been suggested in this country which it is claimed will make successful operation possible here. Different investigators have claimed to be able to produce from 15 to 30 gallons of alcohol per ton of sawdust; at even the lower figure 19,500,000 gallons could have been produced from the sawdust which was absolutely wasted in 1907. This method is, of course, also applicable to the other classes of waste besides sawdust, except possibly the bark.

(2) Sawdust has three marked mechanical or physical properties which give it a certain commercial value. It is elastic, absorptive, and nonconducting. Various minor uses to which it has been put on account of these and other similar properties are here enumerated. These are uses applicable to the sawdust from all species.

Packing material.—The use of sawdust as a packing material for fragile articles for shipment is well known. Its value along this line is shown from the fact that it is used to pack dangerous explosives for transportation. When sawdust is well dried and free from dust, it can be used in contact with polished metal surfaces without rusting or tarnishing them.

Nonconductor.—The intermediate spaces between the joists in buildings may be filled with sawdust to make the walls more nearly "cold proof." The use of sawdust in packing ice to retard melting is well known. Sawdust with plaster of Paris or other suitable binder makes a very good material for covering steam pipes, etc., to prevent radiation of heat.

Absorbent.—Wood flour, or very finely-ground wood, is one of the best known absorbents for nitroglycerin in the manufacture of dynamite. This material is at present made in this country almost entirely from ordinary pulp wood, although in Europe it is made very largely by grinding sawdust. A large saving could be effected if this material were manufactured from a waste product, sawdust, instead of from pulp wood which could be used for other purposes. A common example of the absorptive power of sawdust is found in its use as a stable litter and in public conveyances, meat markets, etc., to keep the floors free from moisture. It also finds extensive employment in the metal industries for drying metallic articles which have been treated with acid, no other substance being so effective in drying and cleaning, and preventing subsequent oxidation such as the formation of rust or verdigris.

Porous brick.—If sawdust is mixed with the clay used in making bricks, it burns out during the treatment in the kiln and leaves the brick full of small cavities. These porous bricks are used instead of hollow tile in partition walls, and are claimed to be even better as a nonconductor. In the year 1900 sawdust to the value of $19,687 was used in the clay and pottery industry of the United States for this or for similar purposes.

Wood substitutes.—The utilization of sawdust as a wood substitute is ideal from the forest conservation point of view, since it makes use of a waste product of the lumber industry as a substitute for the principal product of the industry. There are many methods which have been proposed for manufacturing an artificial wood from sawdust, and some of these have been used on a commercial scale, but progress along this line has been carried further in England and France than in this country. The production of a wood substitute with the elasticity and strength of natural wood is not to be expected, but in moldings, carvings, flooring, paneling, etc., an artificial wood can be very readily substituted. The methods all consist in general of mixing the sawdust with some suitable binding material which hardens on drying or on heating, and then molding the mixture under pressure and heat, or making it into blocks or sheets as the various binders and the various requirements of the product call for. Water glass, glue, rosin, plaster of Paris, blood, casein, etc., and various mixtures of these materials are the binders used. A flooring material made of sawdust and Portland cement is used to a large extent in Germany in place of ordinary plank flooring. It is lighter and more elastic than cement alone, and gives a floor without cracks. A flooring or decking material similar to the above is found on the European markets. This material has been used on the lower and second-class cabin decks of many trans-Atlantic vessels with excellent results. Although materials of this kind have not been extensively used in this country, it is known that wood flour or finely ground sawdust has been used to some extent in flooring, such as linoleum substitutes, and its use as a substitute for the ground cork in linoleum itself has also been reported.

In these various applications of the peculiar physical properties of sawdust there are many possibilities for an expansion of its present use.

Fuel and power.—Probably the one largest use to which sawdust is put in this country is as fuel, but this is almost entirely confined to the immediate plant in which it is produced. Special fire boxes and grates are required, and it is never so satisfactory as larger-sized wood. It is also so bulky that its transportation away from the plant is not economical. It may be stated in this connection that the full fuel value of sawdust is seldom developed under present conditions, mainly because the mills burning it have a very plentiful supply and need not economize. If, therefore, it became necessary or profitable to economize in this respect, much less sawdust could be used with the same results. A method has been suggested for making sawdust more readily transportable and at the same time making it a more satisfactory fuel by pressing it with or without a binding material into briquettes. This method is not profitable in this country on account of the other cheap fuels nearly everywhere available, and on account of the cost of briquetting. As fuel becomes scarcer, however, this plan will become more practicable.

The method by which sawdust can be most economically transformed into power is probably by means of the gas producer and the gas engine, gas producers now being on the market which are claimed to make a gas as consistent in composition and as satisfactory for gas engines as any producer gas made from other materials. The possibilities for the transportation in the form of electrical energy of the power obtained from sawdust through the use of the gas producer and gas engine seem to be greater than for the transportation of the sawdust, either loose or in the form of briquettes.

SECONDARY WASTE.

In 1907, 2,059,496 cords of wood were made into paper pulp by the sulphite process. About 1,030,000 tons of pulp were made from this wood, the remainder, about half the total amount by weight, being left combined with the chemicals used in the form of "waste sulphite liquor." This substance has been investigated by many experimenters in an endeavor to find some method for its utilization. Its uses as a briquette binder, dust layer, sizing for paper, and tanning material have been suggested, but none of these methods have up to the present time attained any commercial prominence. The large amount of this waste material available, however, and the information which has already been obtained regarding its properties surely warrant further investigation.

Pyroligneous acid from pine-wood distillation.—In the year 1907, 61,149 cords of pine wood were distilled in the United States. Probably 45 per cent of this wood, 27,518 cords, was distilled by the destructive process, one of the products of which, pyroligneous acid, is almost entirely wasted. This pyroligneous acid contains wood alcohol and acetic acid, and if these two products were recovered the yield would be about 3 gallons of 82-per-cent alcohol and 50 pounds acetate of lime per cord of wood; 82,554 gallons of wood alcohol and 1,400,000 pounds of acetate of lime were therefore wasted in 1907. The recovery of the materials has never been successful on a commercial scale in this country, although in Germany they are considered valuable products of the process and are saved.

Turpentine from dry kilns.—Probably 30 per cent of the cut of yellow pine for 1907, or 3,964,555,000 board feet, was treated in dry kilns; probably 1 gallon of turpentine on an average was removed from every thousand feet so treated, and none of it was recovered; nearly 4,000,000 gallons were therefore wasted. A process of kiln drying has lately been proposed which claims to remove practically all the turpentine from resinous wood and at the same time to dry the wood quicker and better. If these claims are true there could be recovered probably 3 gallons of turpentine from every thousand feet of southern yellow-pine lumber dried, and there could have been produced in 1907 from the dry kilns an amount of turpentine more than one-third of the total production of gum turpentine in 1905. The complete removal of turpentine from the lumber of resinous woods improves the quality of the lumber, and rapid removal of turpentine vapors from dry kilns tends to reduce the fire risk. On account of these facts, it seems that a process for the recovery of turpentine from dry kilns can be made an economical proposition.

THE DIFFICULTIES.

In the necessarily limited amount of space occupied by the preceding chapters, it has been impossible to treat the subject with which we are dealing with all the detail which might be desired. The most that has been attempted has been to give approximations of the enormous quantity of annual waste, and to suggest some of the possible methods of utilizing it. In attempting to put any of these or other methods into effect, many difficulties are liable to arise, and any attempt here to classify these methods and point out the specific difficulties in employing each or the specific remedies for these difficulties would mean to occupy more time and space than can be had, and would further limit our view of the whole subject. At present it is necessary for a thorough understanding to obtain the broadest possible survey of the mighty task which this nation has before it. The chief difficulty seems to be a general lack of knowledge, not only of the materials to be saved and the products which can be derived from them, but of what has been done in foreign countries along these lines, and of industrial conditions at home—both local and national—which have a bearing on the subject. If more were known concerning the materials to be treated, it would be easier to suggest methods of utilization; if a better knowledge were had of the successes which had been achieved in foreign countries, and of the industrial conditions at home, it would be less difficult to pick out the methods most likely of success in this country. In a sense, there are already available many miscellaneous facts which are of great value, and it is possible to suggest at the outset methods, which, if employed, would lead to greatly improved conditions in the utilization of wood waste, but the employment of all these methods to their full economic value would save but a small portion of the vast quantity of waste. What is needed is more information. At present such as there may be is very scattered, and no one organization is in possession of all the facts or is making an extensive, systematic study of the subject.

In spite of the examples set by sister industries in the utilization of waste and the successes which have been reached, the subject of waste wood has in this country receives scant attention on the part of those immediately concerned. The reason seems to be that while prosperous business conditions prevail, private firms consider themselves too busy to make a careful study of the subject, and can see no immediate necessity for such an investigation; and in times of business depression they do not feel like making the necessary expenditure. In this connection it may also be stated that while the expense would not be greater than some corporations could readily afford, still for the great majority of firms a satisfactory investigation would greatly diminish the profits, and it is doubtful if the quantity of waste which the latter have at their disposal would be sufficient to warrant making the extensive investigation which might be necessary for a solution of the problem. Any investigation of this kind on the part of a small company is usually very limited in its scope instead of being a sound, scientific investigation of the whole subject. Further, industries which have already obtained a footing and might readily utilize wood waste with good profits under proper management remain for years in an unprogressive attitude toward this subject, when the proper application of capital and brains might lead to great developments.

HOW TO ATTACK THE PROBLEM.

First of all it is necessary to collect under one organization all of the available information bearing on the subject, both in this country and in foreign countries, and hold it in such form and place that it can be readily referred to at an instant's notice. This organization should keep in touch with all new developments along this line, and should not only distribute reliable information upon application, but should also actively bring to the attention of the proper persons the necessity of utilizing wood waste and the best methods to employ. Thorough cooperation should be had not only with the scientific men of the country, but also with the practical men of the industries. As many phases of the subject as possible should be studied at the same time, and in close cooperation with each other, and this could best be accomplished by having the work done entirely under one organization. Further, the spirit of this organization should continually be that expressed by the great French writer:

> The human race could increase its welfare almost as much by a better ordering of its consumption as by an increased production of wealth, and this without any retrenchment in consumption.

Certain classes of information can only be obtained by experimentation, and for this reason the organization should be provided with a thoroughly equipped laboratory for carrying on experimental work. The true value of many of the various processes could thus be shown, valuable old ones improved, and new ones suggested. Uses for new products and new uses for old ones could also be discovered, and infant industries in this way would be greatly aided. It may seem logical that the people who have waste wood to dispose of are the proper ones to undertake such experimental work and investigation, but there are many reasons why this is not so and why it is more advisable to have such work done by a central organization. Some of these reasons have already been expressed in the preceding chapter, and in addition it may be said that the results obtained from experiments of private firms would not be available for the use of others, and the good effects would therefore not be widespread. A government organization placed under the supervision of the Forest Service and provided with sufficient funds so that it could operate independently of cooperative money would be an ideal institution for carrying on this work. The ability of the Government to collect certain classes of information is greater than that of private firms, and there is an added advantage that the investigations would be known to be impartial and disinterested and would have the confidence of all concerned; and further, being under the Forest Service, which organization is constantly in touch with those most concerned, the work could be readily carried on in hearty cooperation with all interested parties. The solution of the problem will require time and patience and an organization of more or less permanence, but in the end the results obtained will amply justify a liberal expenditure.

In conclusion, it may be stated that the facts as already known firmly warrant further and more elaborate investigation, and it is earnestly hoped that in the near future an opportunity for making such an investigation will be forthcoming.

WOOD PRESERVATION.

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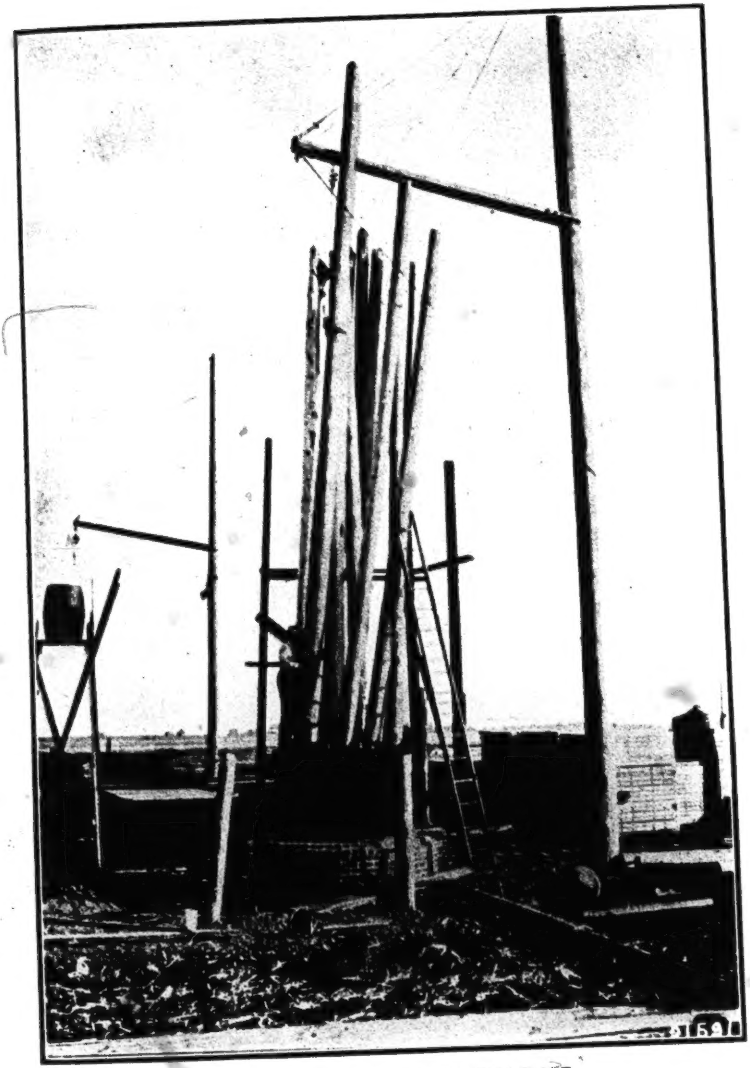
INTRODUCTION.

Wood preservation began in the United States on a commercial scale in 1848, when Mr. James B. Francis, C. E., established a kyanizing plant at Lowell, Mass. This plant is still in operation, although the amount of timber treated in it is comparatively small. About 1874 a creosote-impregnating plant was established at West Pascagoula, Miss. This was one of the first plants of its kind erected in this country and is still in active operation. Since then a number of others have been installed, the most rapid development being along the Gulf of Mexico. The gradual depletion of the timber supply, resulting in an increase in the price of the raw product, has more recently fostered the growth of wood-preserving plants, especially throughout the central and eastern United States. The ravages of shipworms have been primarily responsible for the installation of the plants on the Atlantic, Gulf, and Pacific coasts. In 1904 the total annual output of treated timber in the United States was approximately 500,000,000 feet b. m. In 1907 the number of plants had increased to 60, with a total annual output of approximately 1,250,000,000 feet b. m. New plants are being erected from time to time, and it is reasonable to expect that they will increase considerably in number and capacity.

Creosote is the most common preservative used, although a large amount of zinc chlorid is employed in the treatment of ties for the central western railroads. Experiments are now being carried on by the Santa Fe Railroad Company in treating ties with crude oil. If these prove successful the growth of wood preservation in the West will be very rapid. The high freight rates now existing in the Rocky Mountain States, coupled with the eastern localization of creosote production, have prevented a more rapid expansion of wood preservation in the West. The Forest Service is carrying on a number of experiments in which zinc chlorid is used in combination with crude petroleum. If these or similar experiments prove successful they will result in greatly alleviating this condition.

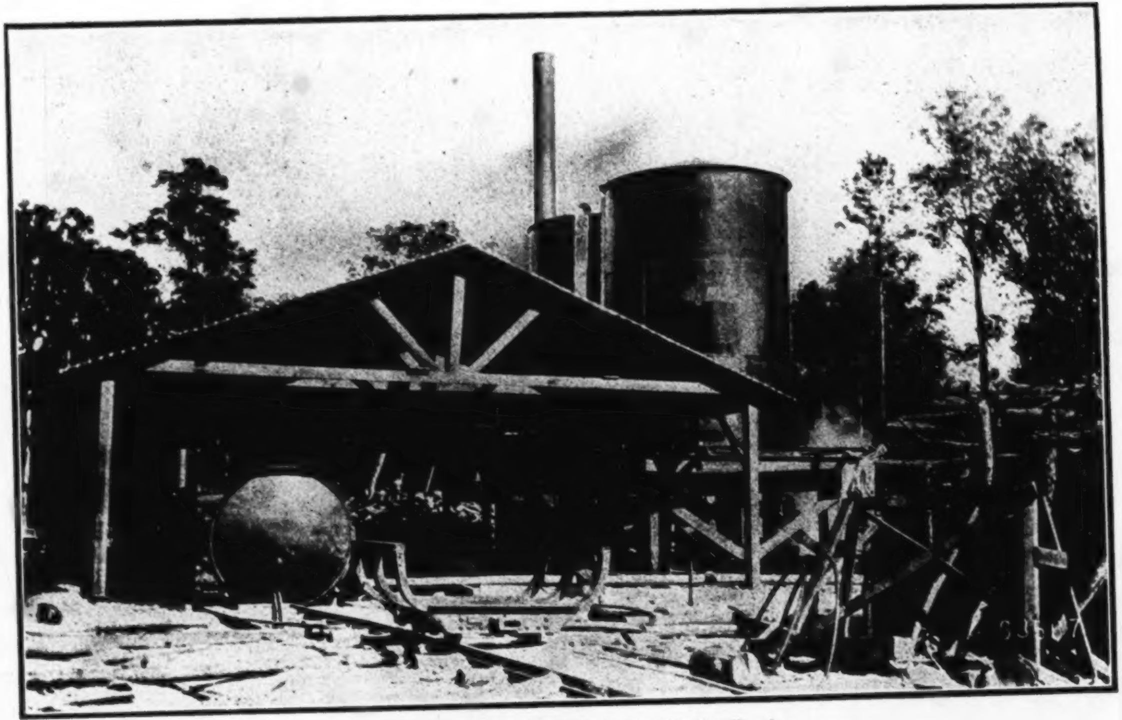
FACTORS INVOLVED IN THE PRESERVATION OF WOOD.

The preservative treatment of timber by chemical and mechanical means permits its more economical utilization by decreasing destruction due to decay, fire, marine borers, insects, and mechanical abrasion.



GENERAL VIEW OF TIMBER-TREATING PLANT.

(Partial submersion.)



GENERAL VIEW OF TIMBER-TREATING PLANT.

(Entire submersion of wood.)

Decay is by far the most serious agency, and affects most timber in contact with the atmosphere, soil, or water. Preservative methods are concerned, therefore, chiefly in protecting timber from this kind of destruction.

An enormous amount of timber is annually destroyed in the United States by fire. The fire loss in buildings in the United States amounts to about $251,000,000 per year. It is particularly desirable that this loss should be decreased, because it is usually accompanied by a corresponding loss of other commodities, and even of life itself. In the larger cities the substitution of materials for wood has tended to decrease the fire loss, but far greater protection can be rendered in the way of impregnating wooden floors, door casings, roofs, etc., with fire-resisting chemicals. Even if the chemicals do not succeed in absolutely checking the fire, its progress can be retarded to such an extent as to render difficult its gaining much headway.

The rapidity with which timber is destroyed by marine borers and the necessity for frequent replacements necessitates a large consumption for such purposes. The fact that thoroughly sound piling is often completely destroyed within a month shows the importance of protection and the wide field for its application. The activities of marine borers extend along both of our coast lines and as far north as Alaska. Next to decay and fire the destruction they cause is of the greatest importance in the preservation of timber.

Insects are responsible for the destruction of a large amount of cut timber each year in the United States. The loss is caused by their boring into the wood and thus fostering conditions for the growth and propagation of wood-destroying fungi.

The destruction of timber by abrasion is largely confined to railroad ties, fender piles, and mine props. The substitution of steel for wood in cars has very greatly decreased the loss due to this cause.

The following commodities should be given preservative treatment, which would result in a financial saving, as well as a more economic utilization of forest products: Railroad ties, poles, mine props, shingles, lumber, posts, and piling.

THE ANNUAL DESTRUCTION OF TIMBER DUE TO DECAY, FIRE, INSECTS, MARINE BORERS, AND MECHANICAL ABRASION.

This information can be best given by a compact table. Table I shows the estimated annual destruction of timber for each class of material adapted to preservative treatment according to each specific destructive agency. The figures are based on the same unit (b. m.) and are only approximations.

TABLE 1.—*Estimated annual destruction of cut timber in United States which can be eliminated or reduced by proper treatment (thousand feet b. m.)*

Class.	Total annual replacements.	Decay.		Fire.		Insects.		Marine borers.		Abrasion.	
		Amount.	Per cent.	Amount.	Per cent	Amount.	Per cent.	Amount.	Per cent.	Amount.	Per cent.
Ties	3,300,000	2,871,000	[a]87	....	....	16,500	½	....	....	412,500	12½
Poles	147,720	140,334	95	....	....	5,909	4	....	....	1,477	1
Posts	3,000,000	2,700,000	90	165,000	5½	120,000	4	....	....	15,000	½
Mine props	402,000	281,400	70	2,010	½	38,190	9½	....	....	80,400	20
Piles	191,520	9,576	5	....	....	....	....	181,944	95	....	....
Shingles	1,100	1,045	95	55	5	....	....	....	....	....	....
Lumber	2,625,000	1,863,750	71	131,250	5	315,000	12	52,500	2	262,500	10
Total	9,067,340	7,867,105	....	298,315	....	495,598	....	234,444	....	771,877	....

[a] This figure includes destruction due to fire as well as to decay.

The annual replacements of each class are found by dividing the total amount of timber in use by the estimated average life of the untreated timber.

EFFECT OF DETERIORATION IN THE QUALITY OF TIMBER UPON THE AMOUNT USED.

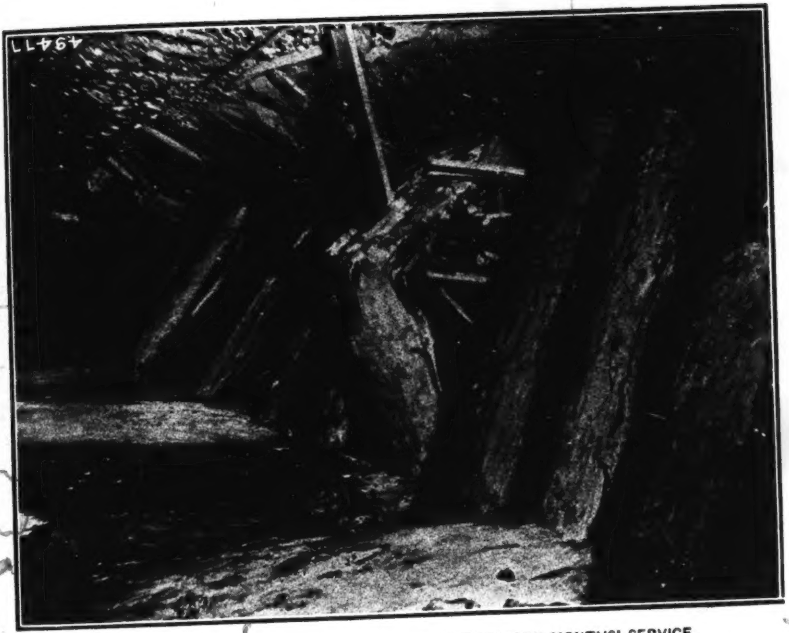
Table 1 shows the annual destruction of timber due to the five agencies mentioned. It is well known that the quality of timber is deteriorating each year, so much so, in many respects, that it has caused a complete revision of the specifications for grading it. This is due mostly to the exhaustion of the better grades, which has forced the utilization of the poorer qualities. Thus, where specifications once rigidly insisted upon first quality white oak for ties, or heart longleaf pine for dimension stuff, they are now given a very liberal interpretation, and species other than white oak are accepted with no difference in price, or considerable amounts of sapwood are allowed on "all-heart" sticks.

This deterioration in quality naturally results in a decreased length of life, which in turn compels a larger annual cut of timber. Hence, the amounts given in Table 1 will increase year by year in direct proportion to the decrease in quality.

HOW WOOD PRESERVATION WOULD LESSEN THE DRAIN ON THE FORESTS.

That the drain on the forests of the country would be materially reduced by a proper preservative treatment of all structural timbers can not be doubted. It is very evident that by prolonging the life of timber a given number of years the amount cut for replacements would be correspondingly reduced. Table 2 shows this very conclusively. It is seen that if all ties, poles, posts, piling, mine props, shingles, and structural lumber adapted to treatment were given a proper treatment an annual saving of about 6,000,000,000 feet b. m. would ensue.

It is a well-established fact that a proper preservative treatment will prolong the life of the decay-resisting species as well as that of an inferior grade. By applying this treatment, it is evident that a reduction in the annual cut for replacements will follow, but since



UNTREATED AND TREATED MINE PROPS AFTER EIGHTEEN MONTHS' SERVICE.

The untreated stick has been weakened by decay and broken.

the increase over the natural life is larger with inferior grades, better financial results will be obtained by their use. The different species of wood, such as cedar, cypress, white oak, etc., which are naturally resistant to decay, have in former years been used to a very great extent. In consequence of this quality, the supply of these species is very rapidly diminishing, and the consumers are of necessity turning their attention to other species formerly largely disregarded on account of their inability to resist decay. The increasing demand for loblolly pine in the South and the lodgepole pine and Engelmann spruce in the West are examples. If these species are used in an untreated condition, they will decay far more rapidly than the timber formerly employed, and a consequent increased annual cut will ensue. Hence, it is essential that they be given a preservative treatment.

To sum up, wood preservation not only prolongs the life of durable timbers, thus decreasing their annual consumption, but also permits the substitution of inferior species, whose use considerably reduces the drain upon the more valuable kinds.

TABLE 2.—*Estimated reduction in annual cut which would ensue from a proper preservative treatment of all timber.*

Class.	Estimated average life, in years.		Estimated annual replacement—all species.		Estimated saving in annual cut (actual quantity).	Board measure equivalent (1,000 feet b. m.).
	Untreated.	Treated.	Untreated.	Treated.		
Ties	7	17	100,000,000	41,200,000	58,800,000	1,940,000
Poles[a]	13	23½	2,462,000	1,380,000	1,082,000	64,920
Posts	8	22	500,000,000	180,000,000	320,000,000	1,900,000
Piles	3½	21½	1,140,000	190,000	950,000	159,600
Mine props	3	13	[b] 67,000,000	[b] 15,300,000	[b] 51,700,000	310,200
Shingles	18	32	[c] 1,100,000	[c] 625,000	[c] 475,000	475
Lumber	8	20	[c] 2,625,000,000	[c] 1,050,000,000	[c] 1,575,000,000	1,575,000
Total						5,950,195

[a] No allowance is made for the fact that the greater percentage of poles now being treated are of so-called "inferior species". When properly treated they will have their natural life increased by more than the general average of 10.25. Hence, by a greater use of these species, there will ensue a corresponding reduction in the annual cut.

[b] Cubic feet.

[c] Feet board measure.

HOW WOOD PRESERVATION WOULD PERMIT SIMPLER AND MORE PROFITABLE SYSTEMS OF FOREST MANAGEMENT.

It has been pointed out that wood preservation brings into use the inferior qualities of timber, thus decreasing the drain upon those species of greater value. It should be noted that these so-called "inferior species" are often rapid growers and prolific seeders. Moreover, as a rule, they possess the requisite adaptability to environment which enables them to persist through a wide range of conditions, even under unfavorable circumstances. Their rapid growth produces a larger volume of wood, and quicker and larger financial returns.

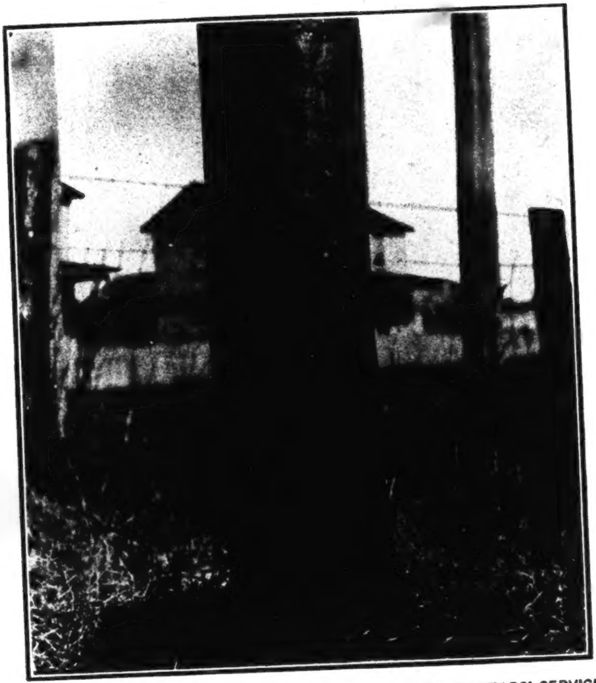
TABLE 3.—*Comparison of loblolly and longleaf pine from the standpoint of wood preservation and forest management.*

	Loblolly.	Longleaf.
Germinating percentage of seed	50 to 80	50 to 70.
Frequency of seed years	1 year	3 or 4 years.
Artificial reproduction	Easy	Hard to handle on account of long tap-root.
Natural reproduction	Good, because of its tolerance and rapid growth. It frequently comes in and drives out the longleaf. Lightness of seed allows wider distribution.	Poor because rare occurrence of seed years allows other species to get the lead. Its slow growth and intolerance cause it to be readily killed back.
Soil requirements	Will not grow in extremely dry soils. Prefers moister situations.	Less exacting; will grow on dry sandy soil.
Rate of growth	Very rapid. 12 inches diameter breast-high at 50 years.	Slow. 8 inches diameter breast-high at 50 years.
Yield per acre	Rotation, 70 years; diameter breast-high, 18 inches; yield, 33,000 feet b. m.	Rotation, 120 years; diameter breast-high, 18 inches; yield 25,000 feet b. m.
Cost of crops per acre (value land, $10;[a] taxes, 3 cents per year; fire protection, 2 cents per year; interest, 4 per cent).	$174	$1,244.
Estimated future value of crop per acre (loblolly, $8 per M board measure; longleaf, $13 per M board measure).	$264	$325.
Total profit or deficit	$90	$919.
Shipping weight, (pounds per M board measure).	3,000	3,500.
Adaptability to treatment	Adapted	Not adapted.

[a] Includes cost of reforesting.

It can be seen from Table 3 that the growth and cultivation of loblolly pine forests result in an annual profit of about $9 per acre more than for longleaf. It must not be construed, however, that this implies the total substitution of loblolly for longleaf, or, abstractly, the substitution of inferior for superior species. Sylvical factors often prevent this, but the fact remains that longleaf pine can not be grown at a financial profit under the conditions outlined in the table.

Many similar examples could be cited showing how a forest composed of the so-called "inferior species" would prove a better investment than one composed of the more valuable varieties. In other words, it is frequently better policy to cultivate rapid-growing trees for ties, posts, poles, piles, etc., and treat them, rather than grow those trees which are naturally durable and which take a long time to mature.



CREOSOTED YELLOW PINE POLE, SOUND AFTER EIGHTEEN YEARS' SERVICE.

INCREASED LIFE AFFORDED BY PROPER PRESERVATIVE TREATMENT.

The increased life afforded by proper preservative treatment is shown in detail for each class of material listed according to species in Tables 4 to 10, inclusive.

TABLE 4.—*Ties.*

Species.	Estimated average number years untreated life.	Estimated average number years treated life.	Species.	Estimated average number years untreated life.	Estimated average number years treated life.
Cedar	11	20	Post and burr oak	7	15
Cypress	10	20	Birch	5	15
Redwood	12	20	Beech	5	20
Chestnut	7½	15	Hemlock	5	15
White oak	8	20	Longleaf pine	7	20
Tamarack	6	15	Maple	5	15
Spruce	6	14	Black oak	4	15
Red fir	7	15			

TABLE 5.—*Poles.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
Cedar	12–15	25	Juniper	10–13	25
Chestnut	8–10	20	Redwood	12–15	30
Lodgepole pine	5	20	White oak	8	20
Western yellow pine	6	25	Douglas fir	8	20
Cypress	12	25			

The best available figures on the life of creosoted poles are from the German postal and telegraph department, which after 52 years of observation gives life of twenty-one years for creosoted Baltic pine poles.

TABLE 6.—*Posts.*

Species.	Estimated number of years untreated life.	Estimated number of years treated life.	Species.	Estimated number of years untreated life.	Estimated number of years treated life.
Cedar	12	25	Redwood	14	25
Juniper	15	25	White oak	8	20
Cypress	12	25	Red oak	5	20
Locust	20	30	Tamarack	5	20
Catalpa	14	20	Chestnut	10	20
Longleaf pine	8	20	Osage orange	20	30
Douglas fir	7	20			

TABLE 7.—*Piles in warm salt water.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
Longleaf pine	2-3	35	White oak	2-3	(c)
Shortleaf pine	2-3	40	Red oak	2-3	35
Loblolly pine	2-3	40	Cedar	2-3	20
Douglas fir	2-3	20	Cypress	2-3	20
Spruce	[a] 8	(b)	Eucalyptus	2-3	(c)
Redwood	2-3	20			

[a] Years untreated life applies if placed in cold water. [b] No records. [c] Not treated.

NOTE.—Red-pine piles creosoted served 46 years. (Clyde Nav. Trust—Glasgow.)

TABLE 8.—*Mine props.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
White oak	5	15	Aspen	2	15
Red oak	3	15	Maple	3	10
Fir	5	12	Hickory	3	10
Hemlock	5	10	Shortleaf pine	3	15
Chestnut	5	12	Tamarack	5	10
Spruce	3	10	White and yellow pine	5	15
Beech	3	15			

NOTE.—The foregoing estimates have been formed without any allowance for the effect of crushing

TABLE 9.—*Shingles.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
Cedar	20	35	Yellow pine	10	20
Cypress	18	30	White pine	15	25
Redwood	18	30	Chestnut	10	20

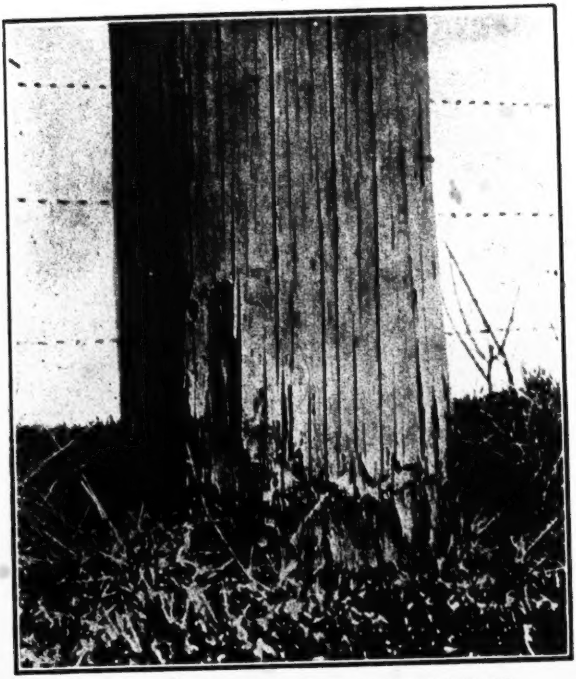
NOTE.—The figures quoted above are only approximations, as there are no available data on the life of shingles.

TABLE 10.—*Lumber set subject to decay.*

Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.	Species.	Estimated average number of years untreated life.	Estimated average number of years treated life.
Yellow pine	8	20	Red gum	4	10
Douglas fir	10	20	Beech[a]	4	20
Oak	8	20	Birch	5	12
Hemlock	6	17	Basswood	4	20
Spruce	6	17	Cottonwood	4	25
Bull pine	6	20	Elm	7	12
Chestnut	12	20	Ash	5	10
Redwood	14	25	Larch	6	15
White pine	8	20	Sugar pine	6	18
Maple	5	16	Tupelo	4	25
Poplar	4	25	Sycamore	3	25
Cypress	14	22			

[a] "White heart."

NOTE.—In this table mechanical wear is neglected and decay alone considered, and this only in lumber placed subject to decay. This does not include doors, furniture, stairs, etc.



CHESTNUT POLE, DECAYED AFTER SIX YEARS' SERVICE.

THE FINANCIAL SAVING RESULTING FROM THE PRESERVATION OF TIMBER.

The financial saving that would result each year in the United States, were a uniform policy of treating timber adopted, is shown for each class and in sum total in Table 11. The total annual saving would amount to about $72,000,000. It should be remembered that this includes the cost of labor as well as that of the timber itself, and thus represents the amount of money that could be turned each year into other channels.

TABLE 11.—*Estimated annual financial saving by proper preservative treatment.*

Class.	Cost.			Cost of treatment.	Years of life.	
	Material.	Placement.	Total.		Untreated.	Treated.
Ties	$0.47	$0.20	$0.67	$0.35	7	17
Poles	4.00	3.00	7.00	1.50	13	23½
Posts	.10	.10	.20	.12	8	22
Piling[a]	.10	.05	.15	.25	3½	21½
Mine props[a]	.045	.23	.275	.11	3	13
Lumber[b]	16.50	2.00	18.5	10.0	8	20

Class.	Annual charge.		Annual saving.	Quantity in use.	Total amount saving.
	Untreated.	Treated.			
Ties	$0.12	$0.097	$0.023	700,000,000	$16,100,000
Poles	.78	.69	.09	32,000,000	2,880,000
Posts	.032	.026	.006	4,000,000,000	24,000,000
Piling[a]	.050	.034	.016	4,000,000	1,800,000
Mine props[a]	.10	.04	.06	200,000,000	12,000,000
Lumber[b]	2.98	2.48	.50	[c]30,000,000	15,000,000
Total					71,780,000

[a] Charges per cubic foot.
[b] Charges per M feet board measure.
[c] Refers only to that adopted to treatment.

NOTE.—The initial cost is taken at the point of purchase, no allowance being made for freight charges.

THE SUBSTITUTION OF MATERIALS FOR WOOD.

In considering the substitution of materials for wood, the use of steel and concrete, both separately and in combination, has undoubtedly far exceeded that of all other materials. When one considers the vast quantity of reenforced concrete now used for all kinds of building and construction purposes, the amount of steel used for towers and poles in electric transmission lines, the number of steel and concrete piles and bridges, and the growing popularity of steel for the construction of railroad cars (which are only a few of the many ways in which these materials have been successfully utilized), it can be seen that the reduction upon the annual demand for structural timbers is considerable, and that the substitution of these and other materials is bound to increase from year to year. Engineers are continually experimenting with different materials with this end in view. Striking examples are the experiments being so widely carried on with steel and concrete railroad ties. Reports from 53 railroads show varied results with such ties during the past few years, but the fact that so many railroads are experimenting along these lines shows conclusively that the importance of the substitution of some material for wood is realized, and there is no reasonable doubt but that in the future some such substitution will be accomplished. Experiments that have been carried on with glass for use in poles are other examples of this tendency.

In substituting inorganic materials for wood, the limited supply of the materials must be kept in mind. Iron, for example, when once taken from the mine, is gone; it can not be renewed. Wood, on the other hand, is capable of growth, and hence of indefinite replenishment of supply from the same area. This fact will cause metals to rise in value, so that the ratio of cost between them and wood for construction purposes will be an ever changing one.

In the manufacture of coal cars, buildings, boats, etc., the substitution of metal for wood has passed the experimental stage. Uncertainly of successful substitution exists at present for ties, poles, piles, light cars and other vehicles, but the large number of experiments that are being carried on promise that here, too, in a large measure, wood will be supplanted. In 1904 the Carnegie Steel Company sold to the trade 11,329 steel railroad ties, and 572,233 in 1907. This company claims that the steel tie is no longer an experiment. The general impression throughout the country, however, is that considerable experimenting must be done before a satisfactory substitute for the wooden tie is found.

No estimate in figures can be given as to the effect the substitution of these and other less popular materials have or will have with regard to the reduction of the annual demand for structural timber. It is too vast for estimation, but it is important that substitutes be used wherever possible, since the available supply of timber is none too large to meet the requirements of industries which of necessity must utilize wood.

CONCLUSION.

Wood preservation began on a commercial scale in the United States in 1848. There are at the present time about 60 plants in operation, with a total output of approximately 1,250,000,000 feet b. m. Most of these plants are located in the South, East, and Central West, but the tendency will be to extend westward as the supply of timber gradually decreases.

The preservation of cut timber reduces its destruction by decay, fire, insects, marine borers, and mechanical abrasion. These factors destroy annually about 9,700,000,000 feet b. m. of cut timber in the United States. Decay is by far the most destructive agency; its retardation, therefore, is of prime importance.

On account of the rapid depletion of standing timber, grades of poor quality are now being sold in the market. This has resulted in more timber being cut each year to do the same work that a smaller amount of the better grades did a few years ago.

Wood preservation, then, accomplishes three great economic objects: (1) It prolongs the life of the durable species in use; (2) it prolongs the life of the inferior and cheaper woods; and (3) it permits the utilization of inferior woods which without preservative treatment would have little or no value.

Quite frequently inferior woods are rapid and prolific growers, and sprout up on cut or burned over areas in such numbers and with such persistence that the slower growing and the naturally more valuable kinds are hopelessly outstripped. Such restocked land has heretofore represented almost a total economic loss, because of the little value of the new crop. Wood preservation has changed this aspect. It has allowed these cheap woods to be utilized, and by so doing has decreased the call for skilled labor necessary to properly manage forests, and increased the revenue that can be derived therefrom.

Other things being equal, the increased life afforded by proper preservative treatment varies directly with the use to which the treated timber is put. Estimates on the increased life of various kinds and forms of timber are approximately as follows: Ties, 10 years; poles, 10¾ years; posts, 14 years; piles, 18 years; mine props, 10 years; shingles, 14 years; lumber, 12 years.

The increased length of life as a result of preservative treatment decreases the annual cut of timber in direct proportion to the increase secured. Table 2 shows that the total estimated saving would amount each year to approximately 6,000,000,000 feet b. m., or about 12 per cent of the total lumber cut. The saving of our timber resources, therefore, is strikingly apparent.

But still further, this saving in material wealth can be brought about by a corresponding financial saving in the cost of maintenance, thereby permitting current expenditures to be placed in other channels. In table 11 the total estimated saving that would accrue as a result of a uniform policy of wood preservation approximates $72,000,000 a year. This estimate includes timber set in position; hence the labor cost of placement is included. Thus it is not only possible to reduce the amount of lumber cut 12 per cent, but to do it at an annual saving of $72,000,000.

The substitution of materials for wood has met with greatest success in heavy construction. Steel and concrete are in most general use, and from the large number of experiments that are being carried on it seems reasonably certain that the field of successful substitution will gradually increase. This will result in very materially decreasing the drain on the forests, but just how much can not be predicted.

FOREST PLANTING.

By A. S. Peck,
United States Forest Service.

INTRODUCTION.

From reports received and compiled by the Forest Service it is estimated that 39,500,000 acres of the forest area of the United States must eventually be restocked by artificial means if this area is to be placed on the highest commercially productive basis. In addition, it is estimated that for the best interests of agriculture a total of 16,500,000 acres of naturally treeless land should be forested in the prairie region and on the irrigated land in the West, making a grand total of 56,000,000 acres. (See Tables 1 to 6.) A beginning in this work has scarcely been made, for the total area of planted timber in the United States amounts only to 962,927 acres, less than 2 per cent of what is needed.

For the purpose of discussing planting, the United States may be divided into an eastern, a central treeless, and a western region. (See fig. 1.)

EASTERN REGION.

This region includes all the country east of the prairie States, comprising the original hard-wood area of the East and the northern and southern coniferous forests. Of the two main purposes of forest planting, commercial and protective, the former is of chief importance in the East. This includes both the growing of timber and the production of material for special purposes. The classes of land which offer opportunities for planting are:

(1) Cut-over and burned-over lands, not fitted for agriculture, which are not restocking naturally with commercially valuable trees.

(2) Forest lands originally cleared for agriculture, which have since proven unsuitable for this purpose.

(3) Farm wood lots.

The most extensive areas of the first class consist of tracts of burned land in the spruce forests of the Northeast and the waste pine lands of the Lake States. Limited areas requiring reforestation occur in southern forests.

The most striking examples of the second class are to be found in the abandoned farms and waste lands of southern New England and the cleared lands of the southern Appalachians, damaged by erosion.

Throughout the hard-wood region generally, wood lots have deteriorated to such an extent that planting is necessary to restore them

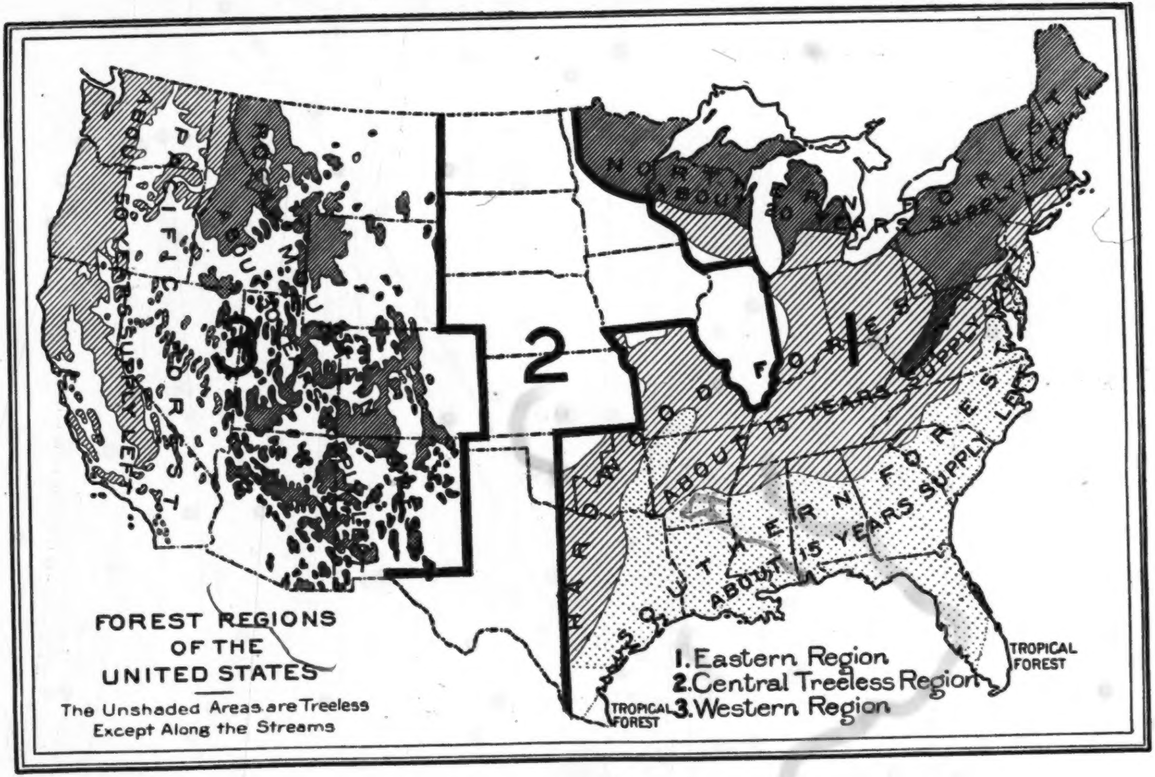

FOREST REGIONS OF THE UNITED STATES
The Unshaded Areas are Treeless Except Along the Streams
PACIFIC FOREST
ABOUT 50 YEARS SUPPLY LEFT
ROCKY MOUNTAIN FOREST
NORTHERN FOREST
ABOUT 20 YEARS SUPPLY LEFT
HARDWOOD FOREST
ABOUT 15 YEARS SUPPLY LEFT
SOUTHERN FOREST
ABOUT 15 YEARS SUPPLY LEFT
TROPICAL FOREST
TROPICAL FOREST
1
2
3
1. Eastern Region
2. Central Treeless Region
3. Western Region

FIG. 1.—FOREST PLANTING REGIONS.

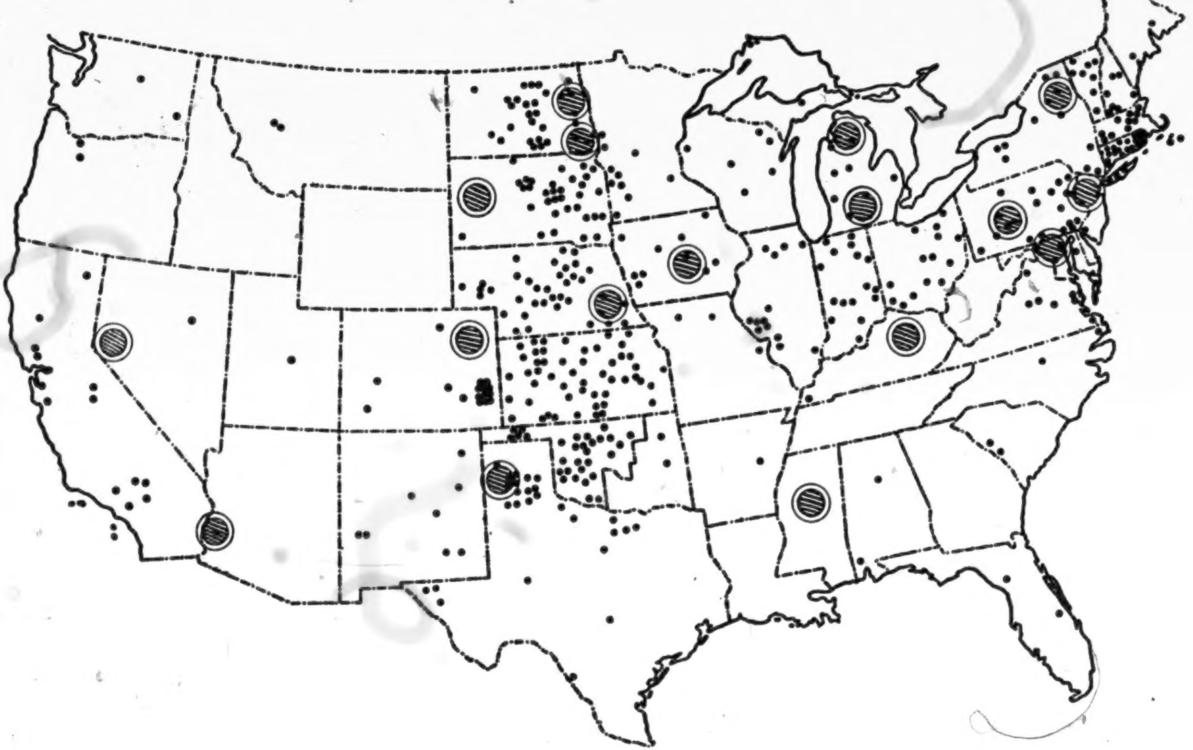


FIG. 2.—FOREST PLANTING.

▨ Points where cooperative nursery and planting experiments are conducted on Bureau of Plant Industry farms and at state institutions.

● Location of planting plans, to July 1, 1908.

to their highest productive capacity. There are also tracts on many farms now lying idle or being cultivated at a small return, which are best suited for tree growth. These will aggregate a large area.

The total acreage of the eastern region requiring planting, 34,538,079 acres, is divided as follows: Northern forest, 17,853,279 acres; hard-wood forest, 11,532,600 acres; and southern forest, 5,152,200 acres.

The area of land upon which planting is necessary or may be practiced to advantage in the States included within the northern forest was computed from the actual area of cut-over lands, secured from the reports covering a certain percentage of each State, with the exception of Massachusetts, Rhode Island, and Connecticut. For the last State the state forester, Mr. Hawes's, estimate of 500,000 acres was used, and for the other two the area of waste land estimated by state officials.

The area of land requiring planting in the States included within the hard-wood forest was computed from the actual area of cut-over lands, secured from reports covering a certain percentage of each State, with the exception of Maryland, where the state forester, Mr. Besley's, estimate of 20,100 acres was used.

The figure given for the southern region does not include 12,000,000 acres not restocking at present in the Southern States, but on which it is considered adequate fire protection will insure natural reproduction.

The earliest plantations of the East were started by New England farmers, usually without any well-defined purpose other than an impression that the rapid removal of certain species must be met by planting. In recent years the purpose of planting has been more specific, including the production of special materials and the use of waste lands. The estimated acreage of plantations in the States included within the forest regions of the East is 93,111 acres.[a] This is divided among the three regions as follows: Northern forest, 43,346 acres; central hard-wood forest, 41,565 acres; and southern forest, 8,200 acres.

The federal and state governments have played a large part in the recent development of interest in planting, and the extent to which it will be practiced in the immediate future depends to a considerable extent upon the assistance and encouragement from these sources. In the past this help has been chiefly by advice and, to a limited degree, through distribution by several States of stock for planting. In the future it will be necessary for state governments to pay more attention to improving the system of taxation of forest lands and providing for adequate fire protection annually.

The Forest Service has, during the past eight years, prepared 181 plans for the planting of 42,687 acres of private lands in the East. (See fig. 2.) Many recent plans are for large areas, entailing planting annually for a series of years, and the acreage planted up to 1908 is a beginning only. Subsequent planting will increase this acreage much more rapidly. During the fiscal year ending June 30, 1908, 2,437 letters asking advice on planting were received from the eastern region and answered, and circulars dealing with the growing of the more important species were widely distributed. A total area of 3,304 acres planted thus far was reported July 1, 1908, as the result of advice given by the Service through planting plans and correspondence. In addition to this, experiments in nursery practice and planting are being conducted in cooperation with state institutions and forest commissions.

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[a] These estimates are based on planting actually reported for a certain percentage of the area.

Eleven States have established nurseries under the supervision of state foresters, in which trees are grown for planting in state forests or for distribution among private landowners.

Forest planting will progress as the need of it becomes more generally felt and its practicability is demonstrated. Since planting requires a considerable initial investment and the cost is relatively higher than that required in inaugurating any other form of forest work, the most important factor governing its practicability is fire protection. Other controlling factors in its success are relatively cheap land, a good market for the class of products to be raised, lowest possible initial cost, and a low rate of taxation.

NORTHERN FOREST.

The northern forest offers the largest field for actual planting by States for commercial purposes and as an object lesson to private landowners. The principal state planting problems of magnitude are to be found in Michigan, Wisconsin, Minnesota, and New York. Except for planting on a limited scale for shelter and the restocking of farm wood lots in the various agricultural districts and the reforesting of abandoned farm lands in New England, planting on private lands will be done chiefly by large corporations. The chief opportunities for such planting are in the northern spruce region by lumber companies and in Pennsylvania by coal companies and railroads.

In the New England States, aside from extensive pitch-pine plantations on the sandy areas of the Cape territory of Massachusetts and the islands of Marthas Vineyard and Nantucket, as nearly as can be estimated on an acreage basis from the data at hand, over 90 per cent of the past planting has been done with white pine. Other conifers which have been noted as doing exceedingly well in particular cases are Norway spruce and European larch.

Examples of mature plantations of hard woods are comparatively rare. In experimental work in Connecticut the state forester finds that chestnut, red oak, locust, and sugar maple promise the best success as far as the experiments have been carried, but the plots have only been established a few years.

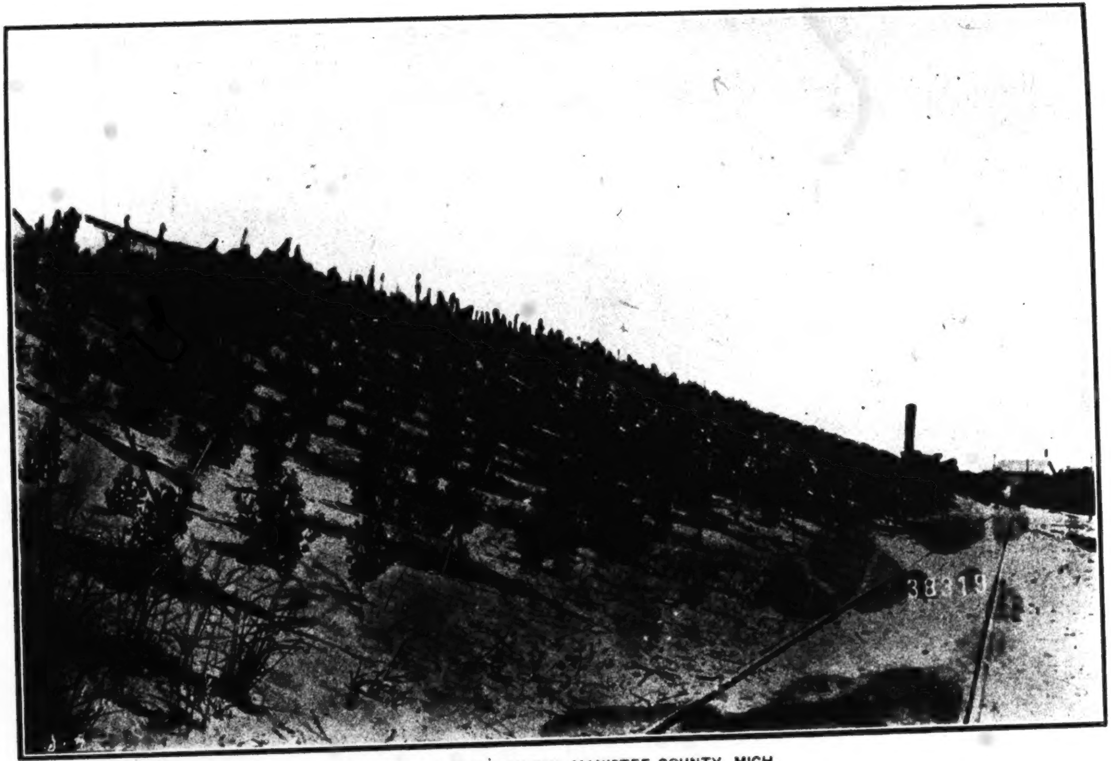
Planting has been chiefly for the following purposes:

1. Utilization of waste sandy areas unfit for cultivation. Over 10,000 acres of pitch pine were planted for this purpose in eastern Massachusetts; 150 acres in Narragansett Bay region.

2. Fixation of shifting sand. Three hundred and thirty-three acres have been planted to beach grass, bayberry, and pine at Provincetown by the Massachusetts harbor commission.

3. Utilization of cheap abandoned farm and pasture lands by wealthy owners as an investment and for improvement of estates.

4. By water companies to keep the supply clean and to produce wood of various sorts. The Metropolitan water board, Boston, has planted 1,100 acres on its watersheds.



SAND DUNE RECLAMATION, MANISTEE COUNTY, MICH.

5. By box-board companies, stave and heading manufacturers, to provide material for future manufacture.

6. By the State for experimental and educational purposes (Connecticut).

The Boston and Maine Railroad has set out 15 acres of white pine, principally for educational purposes. This company is also experimenting with hard woods in various parts of New England.

Past forest planting in the region has been of great economic importance, particularly in Massachusetts, Connecticut, and Rhode Island, in proving the practicability of forest planting for the utilization of sandy waste lands, abandoned farm lands, and for the production of box-board material.

Commercial companies have been aroused through a growing scarcity of timber. Those companies utilizing second-growth white pine began some ten years ago to increase their holdings of pine-wood lots varying in age from forty to sixty years; next they purchased thirty to forty year old stands; then lands having ten to thirty year old stands of pine; and within two years they have begun planting.

The practice of planting is decidedly on the increase, especially in Massachusetts, Connecticut, New Hampshire, and Vermont, but in Maine to a lesser degree. It is not on the increase in Rhode Island, but will undoubtedly be taken up when efficient fire protection and proper taxation are secured.

The progress by periods in Massachusetts has been estimated as follows: 1820–1880, 10,000 acres white pine planted;[a] 1880–1894, little planting done; 1894–1902, about 5,000 acres planted.[b]

During 1908 over 2,500 acres have been planted in New England.

Connecticut, Massachusetts, and Vermont distributed about 1,500,000 seedlings last year, which have not supplied the demand. One private firm disposed of 1,000,000 seedlings. Beginning in the spring of 1907 the state nursery of Vermont has since distributed or helped order perhaps 100,000 seedlings per year. This quantity, although relatively small, has been of quite disproportionately high educational value, since on account of it some fifty to one hundred other persons scattered over the State have made small trial plantations and have succeeded so well that they will continue the work. Almost every farmer in Vermont may wisely do a certain amount of planting under the direction of the state officials. The most hopeful places to begin the practice of forestry are the old, weedy back pastures which are now lying practically waste. Next to this is the filling in of blank spaces in natural stands. The farmer in Vermont will undoubtedly improve and plant his wood lot before the lumberman takes up planting to any great extent. It will, in fact, become a regular part of farm management.

White pine is considered the species surest of success. Red pine is of great value, especially for the drier soils, and the state experiment station is using Scotch pine on dry sands. Norway spruce is of especial promise for moist, strong land of the high mountain valleys—that is, all the natural spruce land. Small plantations of black locust are being tried for the purpose of producing posts and stakes.

In the immediate future State Forester Hawes believes that the greatest amount of planting in Connecticut will be done by wealthy owners as a side investment.

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[a] Bulletin 45, The Planting of White Pine in New England, Bureau of Forestry.

[b] Estimate of H. B. Kempton, Woodland and Roadside, March 1, 1903.

In New Hampshire, Forester Ayres thinks that there will not be much planting purely for timber supply in the next few years, but that a great deal of planting will be done on a small scale as a part of farm management. There are several instances of plantations just started by manufacturing companies. One of these, a cooperage company, has planted 225 acres of white pine on a fifty to sixty year rotation, for stave and heading stock. Water companies in general are reported to be taking up a forest policy. In New Hampshire the species proving most suitable for planting are white pine and Norway or red pine for sandy soils and Norway spruce for loamy soils.

In Massachusetts wealthy land owners are doing considerable planting. State Forester Rane has distributed white ash (one-year seedlings) on a large scale throughout the State during 1907 and 1908. Experiments with this species so far in Connecticut have proven unsatisfactory.

In Connecticut the conifers best adapted for planting on the sand plains are Scotch pine, white pine, Norway pine, and pitch pine, and the hard woods which promise best are chestnut, red oak, locust, and sugar maple.

It is estimated that there could be harvested to-day from plantations in New England about: White pine, 5,000,000 feet b. m.; chestnut, 25,000 feet b. m.; locust, 4,000 feet b. m.; and other hard woods, 5,000 feet b. m.

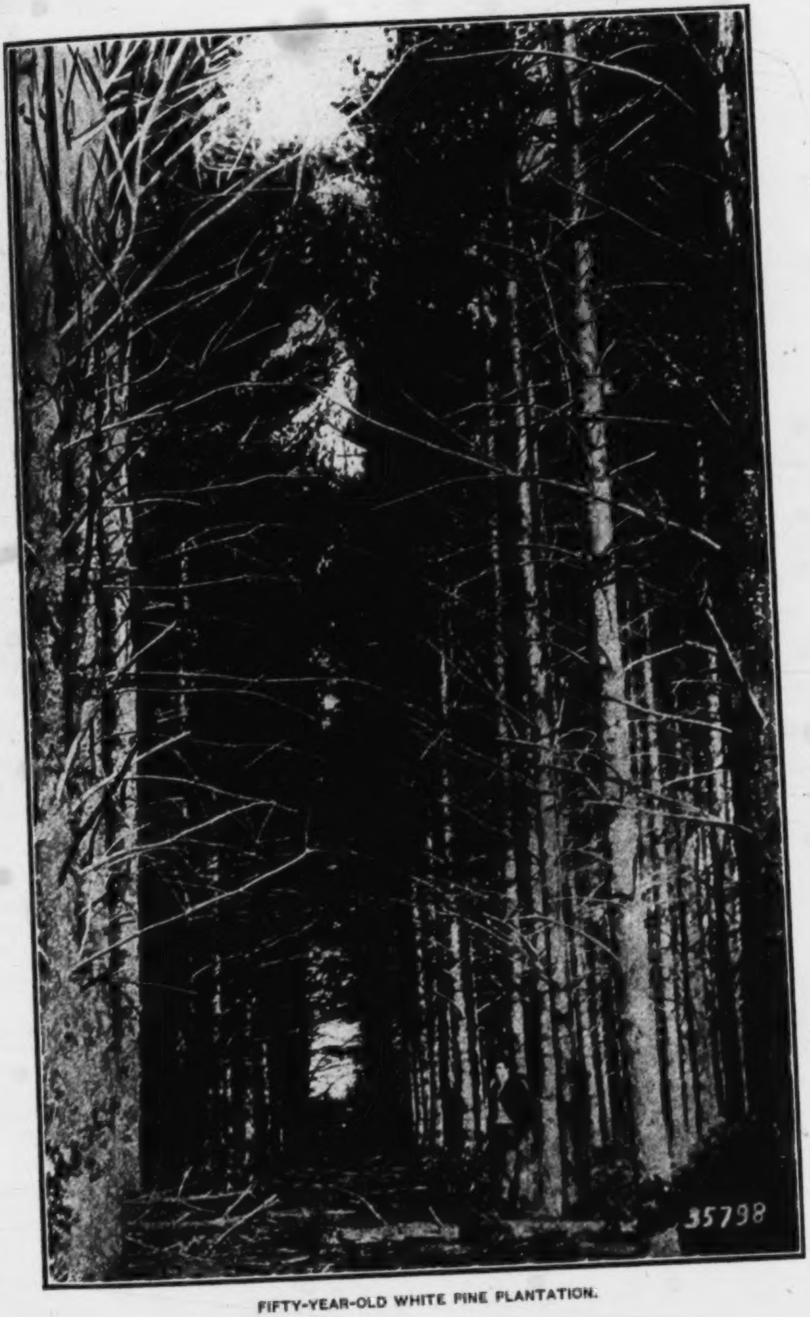
The great bulk of the plantations of white pine now in existence have been established within the last few years and will not be ready to harvest before 1930 at least. Something like 200,000,000 feet b. m. could be harvested between 1930 and 1950 from plantations already established if they are successfully maintained. Granting that one acre will yield 25,000 board feet at the end of forty years, all the stock planted in 1908, if successfully raised and harvested, in 1948 would yield 62,500,000 feet b. m.

The increasing field for forest planting in the New England States is indicated strikingly by the rapid decrease in recent years of the area of improved land in farms. This decreased from 11 per cent in Maine to 20 per cent in New Hampshire between the years 1890 and 1900, according to census figures. There are 2,500,000 acres in New England needing planting.

In New York State, aside from the restocking of forest lands in the mountain regions, forest planting is advisable for improving and renewing farmers' wood lots and making productive the waste areas on farms. The chief purpose of planting will be timber supply, and the species which are best adapted and which promise highest returns are white pine, red pine, Norway spruce, chestnut, red oak, basswood, tulip poplar, white ash, and in moist places Carolina poplar. The practice of planting is increasing rapidly. The work of the State in the Adirondacks is a remarkably fine example of good nursery practice and planting.

Pennsylvania divides readily into three sections where conditions of surface, soil, and climate are enough differentiated to modify the practice of tree planting in each.

The southeastern plains extend from tide water along the Delaware westward and northeastward along the Blue Mountains, which form



FIFTY-YEAR-OLD WHITE PINE PLANTATION.

the northern boundary of Cumberland, Lebanon, Berks, Lehigh, and Northampton counties. This was an early settled farming region, nearly every farm having its wood lot. Very few of these wood lots are in good condition, and in some cases this has caused the owners to become interested in forestry, and more or less tree planting has followed. The average prices of cordwood and fence posts and farm repair material generally are higher in this section than in any other portion of the State. This feature, coupled with the value of the land for agriculture, makes this region a splendid field for farm planting for quick-growing species that will produce in a comparatively short time fence posts and other timbers needed on the farm. More planting has thus far been done in this section of the State than in any other. The early purposes of planting were rather vague. Two classes of species were used—white pine, which was extensively planted and leads the class of slow growers, and the black locust, the most frequently planted of the rapid-growing species. No great degree of success has been attained, and the chief value of the early planting has been the creation of a general interest in tree planting among the people and the determining of the value of various species for planting. The great area of the near-by central mountain region, which is more valuable for tree growing than any other crop, makes it undesirable to devote these plains to other than rapid-growing species for the production of small-sized material.

Species which seem to give the best promise for planting are red oak, European larch, tulip poplar, and, where the wood can be given preservative treatment, cottonwood, silver maple, white willow, loblolly pine, and pitch pine. Catalpa has proven successful enough to justify its limited use on rich soils, and, with proper methods of growth, should prove a valuable post tree.

The central mountains comprise a broad belt extending from the northeastern part of the State southwestward to Maryland and West Virginia. This entire section was covered originally with splendid forests of pine, hemlock, and hard woods. The presence of unexcelled markets on the lake toward the north and along tide water toward the south will make the practice of forestry in this section as profitable as in any portion of the East. Excepting over the barren portions of watersheds that are supplying water for domestic use, there is no section of these central mountains in which extensive tree planting will be necessary, especially in view of the present inability of the owners, whether State or individuals, to protect their lands from fire. While the danger from annual or periodical fires is as great as now, it will not be a profitable thing to attempt to increase the value of these forests by general planting. As soon as the fire danger is diminished, natural reproduction will undoubtedly restore a forest cover that would compare well in density and composition with the original forest and should be supplemented by planting. In the central mountains the planting should be of white pine and spruce, and hardwoods such as red and scarlet oaks, tulip poplar, white ash, and basswood.

The western hills comprise a section in the northwestern part of the State extending from the Allegheny River westward to the Ohio line and Lake Erie. This section ranks next to the southeastern plains in agricultural value, yet contains a much larger amount of land adapted to tree planting in proportion to the total area.

The practice of planting would undoubtedly add materially to the general value of both farm and forest areas. Since there are considerable areas of essentially nonagricultural land separating the agricultural sections, slower growing species for the production of large timbers could be used profitably, while, as on the southeastern plains, quick-growing species may be planted to advantage on many of the farms. Thus far very little planting has been done in this section. In the western hills the soil is admirably adapted to white pine, European larch, and such hardwoods as red, yellow, and scarlet oaks, white ash, basswood, honey locust, and such rapid-growing species as cottonwood, soft maple, and white willow.

In the Lake States the practice of planting is increasing rapidly. They are divided into a southern hard wood forest and northern coniferous forest. The principal species planted have been white pine, Scotch pine, Norway pine, European larch, and, to some extent, the more rapid growing hardwoods such as locust, catalpa, black walnut, cottonwood, ash, and elm. In these States, where there is the greatest field for reforestation of cut-over lands, the united work of private individuals and of the state governments in reforesting nearly 13,000,000 acres will mean the rebuilding within seventy-five years of the lumber industry, which at its period of greatest activity produced nearly 40 per cent of the total cut in the United States.

CENTRAL HARD-WOOD FOREST.

In the States included within the hard-wood forest, planting will be done by farmers, to a limited extent, for protection from winds and to check erosion, but chiefly for the utilization of waste lands on farms; by mining companies, railroads, and manufacturers on nonagricultural lands for the production of pulp wood, box boards, mine props, ties, piles, posts, etc. The work of the various state governments in this region will be largely confined to assistance and encouragement of planting by various means, such as the distribution of publications containing advice and information, distribution of stock from state nurseries, and the conducting of forest work on state reserves, which will serve as an object lesson to private landowners. Such reserves on which planting is already being done are owned by Connecticut, Indiana, Michigan, New Jersey, New York, and Pennsylvania.

In New Jersey the principal species which have been planted in the past are white pine, Scotch pine, white ash, and white elm for purposes of timber production. The practice of planting is increasing greatly. It is, however, considered by the forester of the state forest park reservation commission to be relatively unimportant, and necessary only on abandoned fields. The species which give the best promise are the most rapid growing of the conifers.

In the central valley States the species chiefly planted have been as follows: West Virginia and southwestern Pennsylvania, walnut, locust, sugar maple, red oak, chestnut, and catalpa for posts, mine props, and timber; Ohio, black locust and catalpa for posts; Indiana, black locust, catalpa, and walnut; Kentucky, black locust, catalpa, tulip poplar, maple, and walnut, principally for mining timbers and posts; Tennessee, locust, maple, and cedar; Missouri, catalpa, locust, walnut osage orange, cottonwood; and Arkansas, locust and walnut.

20-YEAR-OLD BLACK WALNUT PLANTATION FROM SEED, TIPPECANOE COUNTY, IND.

SOUTHERN FOREST.

In the southern forest region the artificial restocking of denuded areas will be almost wholly the concern of lumber companies and other large landholding corporations and will consist chiefly of seeding with native pines to supplement the protection and management of forest lands, which for the most part are reproducing naturally.

Of the total area of cut-over forest land which is not restocking naturally, it is estimated that probably 70 per cent will reproduce well to pine if protected from fire for a long enough period. Thirty per cent, or 5,152,200 acres, is therefore given as the area requiring artificial restocking. While most of this area lies within the southern pine forest, there are limited opportunities for planting in the Appalachian Mountain region and in the northern portions of Georgia, Alabama, and Mississippi. Planting thus far has been almost altogether of rapid-growing hard woods, such as catalpa, and was for the most part ill advised. It serves as no indication at all of the lines along which planting will progress in the future. The hardy catalpa is practically unsuited for planting in any portion of this region. For quick production of material in small sizes, black locust is especially well adapted for the mountain and Piedmont sections of Georgia. The white oak is well adapted for planting in Georgia for the production of posts, ties, etc. For post production it will, however, probably prove most profitable to grow loblolly pine and treat it with preservatives. Carolina poplar grows rapidly in the South and makes good chemical pulp. The practicability of planting this, however, is somewhat in doubt, since it has been found that pine can be used for pulp.

In general, it may be said throughout this region that planting is unnecessary, since reproduction of the longleaf and loblolly pines is abundant wherever cut-over forest lands or abandoned farm lands are protected from fire.

CENTRAL TREELESS REGION.

The area included within this region comprises the States of Illinois, Iowa, North Dakota, South Dakota, Nebraska, and Kansas, the prairie district of Minnesota, and the portions of Oklahoma and Texas lying west of the hard-wood belt.

Tree planting in this region was begun on a considerable scale some thirty or forty years ago, to provide shelter from the heavy winds. In extent of past planting, it is the most important region of the United States.

An effort was made to stimulate interest in planting on the western prairies and plains in the years 1873–74 by the passage of timber-culture acts. Many tree claims were started in the treeless region under these acts, but owing to the crude provisions of the law and the lack of knowledge regarding planting on the part of the homesteaders, the securing of much land by fraudulent means resulted and the planting accomplished has in the aggregate been of relatively small value. The law was repealed in 1891.

Planting has followed the progress of agriculture, and has been most extensive in the region of best agricultural development. Nebraska and Kansas lead in the acreage of plantations. Assessors' figures compiled in 1904 indicate that Nebraska had 286,000 acres of planted timber at that time, and it was claimed that Kansas had 142,984 acres of plantations in 1900. The area of private forest planting of which there is record in all the States included within this region is 752,443 acres. The total estimated area of past planting is 830,954. That which should be devoted to this purpose is estimated to be in the aggregate nearly 15,000,000 acres.

In early planting for protection, the tendency was to make use of rapid-growing species which could be obtained cheaply, without regard to their final commercial value in plantations. Owing to poor selection of species, indiscriminate planting on sites not suitable for the species used, and ignorance of proper methods, much of this early planting has given very poor results. As a result, however, of the very large extent to which planting has been done under widely diverse conditions, the problems of this region are fairly well solved and the lines of future development clearly indicated. Sufficient success has been attained to demonstrate that, with a right choice of species and methods, forest planting for commercial purposes is practicable.

As in the past, planting in this region will be almost entirely a private enterprise, carried on in connection with farming. While protection is and will be in general the primary object, planting will be done from the commercial standpoint, since by using only profitable species it will easily be possible to secure the advantages of shelter and ornament, and at the same time derive a revenue from all the plantations.

Until quite recently planting was for a number of years on the decline or at a standstill in the older farming regions of Illinois, Iowa, Nebraska, and Kansas. The cutting of mature plantations offset in acreage what new planting was being done. As might be expected, the planting of shelter belts is greatly on the increase in the newer farming districts of the Dakotas and Oklahoma, and, owing to the increasing evidences of the value of plantations, interest in planting is again being revived throughout the region. The following figures, giving the comparative distribution of stock for the past three years, by forty-five of the principal commercial nurseries which handle forest-tree seedlings, show the increase of interest, since the greater portion of this stock was sold for planting in the prairie region: 1906, 24,530,929; 1907, 38,540,202; and 1908, 40,791,193. Of these trees, 70 per cent were hard woods and 30 per cent conifers.

The advantages and the necessity in most cases of having a certain proportion of the land in agricultural districts under forest cover have been clearly demonstrated, and it is considered that 5 per cent of the prairie region should be forested for the best interests of agriculture. Farther west on the plains, 3 per cent of the land may very well be devoted to tree growing. The ninety-ninth meridian is arbitrarily used as the dividing line, 5 per cent being used for States or parts of States east of this meridian and 3 per cent west. Figures on the area of land that should be planted are obtained by subtracting the area of land already planted from 5 per cent or 3 per cent of the total area, according to the location of the State.

PLANTATION OF HARDY CATALPA, KANSAS.

27-YEAR-OLD EUROPEAN LARCH PLANTATION, ILLINOIS.

Figuring on this basis and that of the acreage already forested, there remains 14,160,246 acres on which planting is very desirable and may be done to good advantage. In addition to this there are about 653,352 acres of grass land in the sand-hill district of western Kansas and Nebraska, now under the control of the Federal Government, as much as possible of which it is intended to forest for the production of commercial timber and as an object lesson to the people of the region.

Owing to the fact that the opportunities for tree planting and the practicability of it became earliest apparent in the treeless States, the first efforts of the Forest Service for the encouragement of planting were directed toward this region. Since 1899, 223 planting plans have been made for private landowners, covering a total acreage of 5,488. (See fig. 2.) During the fiscal year ending June 30, 1908, 1,129 letters asking for advice on planting were received from this region and answered, and there has been a wide distribution of circulars dealing with the results of careful studies which the Service has made of the districts most important from the tree-planting standpoint. Up to July 1, 1908, a total area of 1,072 acres has been reported planted as the result of advice given by the Service by planting plans and correspondence. Experiments to determine the value of various species and methods are being conducted in cooperation with the States of North Dakota, Nebraska, and Iowa.

All of the States in this region have taken more or less interest in forest planting. Minnesota expends $20,000 annually in bounties for tree planting in the prairie sections of the State. Kansas maintains a state nursery, from which trees are distributed to private landowners, and experimental planting is being conducted by state institutions in six of the States. Owing to the nature of the planting problems in this region, the future action by States will be wholly along the line of demonstrating to private landowners the practicability of planting and the best methods.

ILLINOIS.

Although the southern portion of this State is properly included within the central hard-wood region, it is considered a prairie State. Seventy per cent of the total area was reported upon by county clerks; 10,898 acres of planted timber were reported, making the estimated total of past planting 15,568 acres. The area upon which planting is desirable is 1,456,526 acres. According to reports received, the practice of planting is waning. The species chiefly used in the past were black walnut and hardy catalpa, and the chief purposes were for shelter belts, for production of posts, and for fuel.

IOWA.

Prof. C. A. Scott estimates the area of past planting to be 125,000 acres. While this figure is considerably more than that reported by county clerks, it seems reasonable, and was used. The area upon which planting is desirable is 1,929,752 acres. Planting is reported to be decidedly on the decline. The species reported to have been planted chiefly are, in the order of their predominance, silver maple, black walnut, cottonwood, boxelder, willow, ash, elm, and catalpa. Shelter ranks first among the purposes of planting, with fuel, posts, and timber supply next in order.

MINNESOTA.

The western and southern prairie portions are included in this region. The total amount of past planting, as estimated by General Andrews, state forest fire warden, is 115,000 acres. The area of land which should be planted is 1,178,728 acres. The practice of planting is reported to be slightly on the increase. The species which are most commonly planted are boxelder, cottonwood, maple, willow, ash, and elm, for purposes of timber production, shelter, and fuel.

NORTH DAKOTA.

An area of 44,746 acres of planted timber was reported from 86 per cent of the area of the State. The total area of past planting is estimated at 52,030 acres. The area upon which planting should be done is 1,578,000 acres. Three per cent of the area of irrigation projects in this State (2,280 acres) is also included in the total to be planted. Planting over the entire State is reported to be increasing rapidly. The species chiefly used are boxelder, cottonwood, green ash, and willow, and the chief purposes of planting are for shelter and post production.

SOUTH DAKOTA.

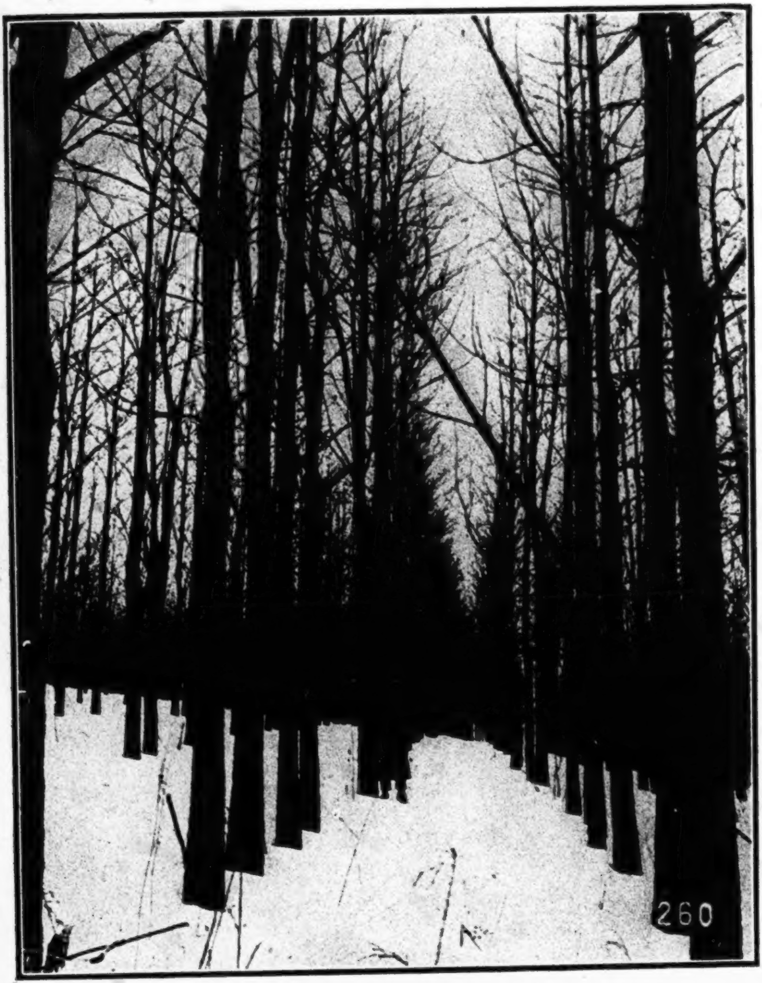
The actual area of planted timber, secured from reports covering 71 per cent of the total area of the State, is 86,638 acres. The total area of past planting is estimated at 122,025 acres, of which 110,462 acres are east of the ninety-ninth meridian. The total area of land upon which planting is desirable is 1,788,238 acres. This includes 3,000 acres of land on irrigation projects and 150,000 acres of land requiring planting in the Black Hills National Forest. Planting is reported to be on the increase in this State. Boxelder, ash, cottonwood, elm, and soft maple are the species chiefly planted, for purposes of shelter, fuel, and posts.

NEBRASKA.

An actual area of 167,137 acres of planted timber was secured from reports covering 87 per cent of the State. The estimated total area of past planting is 191,996 acres, of which 133,541 acres lie east and 58,455 acres lie west of the ninety-ninth meridian. The area in the State which should be planted is 2,093,803 acres. The total includes 900 acres of land on irrigation projects and 556,072 acres within the Nebraska National Forest. The practice of private planting is reported to be slightly declining. The species chiefly used in the past have been cottonwood, boxelder, ash, elm, and maple, for purposes of shelter, fuel, and posts.

KANSAS.

Reports were received covering practically the entire State. The total area of planted timber is 175,023 acres, of which 154,131 acres



21-YEAR-OLD PLANTATION OF HARDY CATALPA, IOWA.

PROTECTIVE AND COMMERCIAL PLANTING YANKTON COUNTY, S. DAK.

lie east and 20,892 acres west of the ninety-ninth meridian. The area which should be planted is 1,963,853 acres. The total includes 240 acres of land on irrigation projects and 302,387 acres within the Kansas National Forest. The practice of private planting seems to be about at a standstill. The species chiefly planted have been cottonwood, black locust, hardy catalpa, black walnut, and ash, for purposes of shelter and production of posts and fuel.

OKLAHOMA.

Only that portion of the State which lies west of the ninety-ninth meridian has been included in the central treeless region. The area of planted timber in this portion of the State is 21,143 acres, secured from reports covering practically the entire area of the region. The area which should be planted is 317,044 acres, which includes 5,000 acres of land requiring planting within the Wichita National Forest. The practice of planting in this region is increasing rapidly. Locust, catalpa, maple, and cottonwood are the species chiefly planted, for purposes of post production, shelter, and fuel.

TEXAS.

Only that portion of the State which lies west of the ninety-ninth meridian is included in this region. Of past planting 6,848 acres were reported from 52 per cent of the total area. The estimated area of past planting for this portion of the State is 13,169 acres. The area which should be planted is 2,507,651 acres. This includes 1,800 acres of land on irrigation projects. The practice of planting is reported to be increasing very rapidly. Black locust, cottonwood, and catalpa are the species chiefly planted for purposes of shelter and the production of posts and fuel.

WESTERN REGION.

This region includes the Rocky Mountain and the Pacific coast States. Nearly all of the forest land in the western States, with the exception of Washington, Oregon, and California, is within national forests, thus making forest planting on these lands chiefly a federal problem. Aside from this, the principal opportunities for planting occur in the valleys of southern California and on irrigated lands throughout the region. The total area of land which it is essential should be forested is over 7,000,000 acres.

PRIVATE FOREST PLANTING.

On irrigated lands the primary purpose of planting by private owners is identical with that of the central treeless region. Most of the projects are so located as to be subject to strong winds, and protection is essential. Forest planting by individuals in California includes both protection of orchards and the production of commercial timber.

The total area of planted timber in this region is estimated to be 38,862 acres, of which 37,100 acres have been done by private landowners. This estimate is based on the area of past planting actually secured from county reports. The most interesting and economically valuable planting in the region is (1) an aggregate of 20,000 acres of commercial plantations of eucalypts in California and (2) the annual planting work of a paper company in Oregon for the production of pulp wood, a total of 1,100 acres up to 1908. The former presents one of the most remarkable cases of profitable returns from a quick-growing species, and shows the value of further experiments with exotic species in the United States. The latter is a notable example of the feasibility of planting for a special purpose, even in a well-timbered region.

If the proper species of trees are used, the difficulty of securing good shelter belts and woodlots will be no greater on western irrigated lands than in the central treeless region. Eastern species of trees have proved most useful in the small amount of planting done thus far. Ash, cottonwood, locust, and elm, introduced species such as Norway spruce and Scotch pine, and many other trees have been planted. The choice of species depends chiefly upon latitude and altitude since moisture can be controlled by irrigation. There is often such a wide difference in conditions within a section of a State that different trees must be chosen. For example, in the upper Snake River Valley, in eastern Idaho, only hardy conifers and broad-leaf trees are suitable, while in the western part of the State, in the lower Snake River Valley, nearly all eastern hard woods may be grown.

There are now about 11,000,000 acres of land under private irrigation, and there will be 1,910,000 acres under government irrigation by 1911. There yet remains 60,000,000 acres judged to be susceptible eventually of irrigation. At least 3 per cent of such land may be devoted to tree growing to good advantage, and if this is done planting will have shelter as its chief purpose, but incidentally the production of useful farm materials.

The development of planting in California has been more rapid than in any other State in the region. High returns from plantations have already been secured, and the southern part of the State is likely to be a great producer of eucalyptus (hard wood) timber for many uses, especially furniture and wagon stock.

It is estimated that there are at least 1,000,000 acres of land in the valleys of southern California upon which continued irrigation for the production of fruit is not feasible, but which can be irrigated temporarily and are well suited for the growing of eucalypts. The principal work of the State in this connection thus far has been in the nature of advice and giving out publications dealing with planting.

The Forest Service has during the past few years made examinations of 15 of the 28 government irrigation projects to determine the species best adapted for planting by settlers, and experiments in tree planting are being conducted on several of the projects. Since 1900, 48 planting plans have been prepared for private landowners in the States included in the western region, covering a total of 15,779 acres. (See fig. 2.) Approximately 809 letters asking advice on planting were received and answered during the year ending June 30, 1908, of which 460 were from California; in addition, a very large amount of correspondence has been answered by the state forester. Partial returns show that 470 acres have been planted up to

GOVERNMENT EXPERIMENTAL PLANTATION OF JACK PINE, HOLT COUNTY, NEBR.

EUCALYPTUS WINDBREAK PROTECTING LEMON ORCHARD, SAN BERNARDINO COUNTY, CAL.

July 1, 1908, as the result of advice given by the Service through planting plans and correspondence.

The principal forest lands outside of national forests lie in Washington and Oregon west of the Cascades, and in California. Possibly 25 to 30 per cent of cut-over lands in the former section will be devoted eventually to agriculture. Adequate fire protection and proper forest management will provide for a future timber supply on the balance of these lands. Planting will be a small factor only and supplemental to forest management, in order to restock areas that can not reseed naturally because of lack of seed trees.

It is estimated that in addition to the national forest land requiring planting an area of 276,640 acres of cut-over private lands must be artificially reforested, and that tree planting is desirable on 2,586,340 acres on irrigation projects and other treeless farming regions. In preparing these estimates for that portion of the region not included within national forests, the area of cut-over land not restocking naturally in private ownership was found by computing from figures secured from county reports. To these amounts were added 3 per cent of the area of irrigation projects to be completed by the Reclamation Service by 1911, and 3 per cent of the area of farm land in each State, less the area of past planting in that State.

NATIONAL FOREST PLANTING.

Over 5,000,000 acres in national forests will require planting eventually. The following table shows the area to be planted by States:

State.	Area requiring planting in national forests.	State.	Area requiring planting in national forests.
	Acres.		*Acres.*
Arizona	255,000	Oklahoma	5,000
California	1,113,500	Oregon	150,000
Colorado	932,500	South Dakota	150,000
Idaho	228,000	Utah	174,000
Kansas	302,387	Washington	103,500
Minnesota	10,000	Wyoming	637,000
Montana	434,000		
Nebraska	556,072	Total	5,276,959
New Mexico	226,000		

The total area to be forested represents approximately 3 per cent of the total area of all national forests. These figures are based on the reports of supervisors and other officers of the Forest Service; in many cases the acreage has been determined by a careful examination of the forest. The areas given for Kansas and Nebraska consist of treeless sand-hill land; that given for California includes chaparral land, some of which was never natural forest land. With these exceptions the 5,000,000 acres represent natural forest land that has been denuded by lumbering and fires and which must be planted if it is ever to become productive. After considerable experimenting it may also be found possible to afforest a larger area in addition to this, such as brush lands in the arid region.

There are two principal purposes in future national forest planting—protection of important watersheds and the production of commercial timber. The distinction made in classifying protection areas is the importance of the denuded slopes in protecting the water supply of near-by towns and cities, and streams furnishing water for irrigation projects in the immediate region. Lands to be planted that have a more remote protective influence, and the chief importance of which lies in planting them to make the land productive again for future needs, have been classified under commercial planting areas. Both purposes are often involved, but the areas given above may be divided according to purpose, as follows:

	Acres.
Protective planting:	
City watersheds	280,000
Irrigation watersheds	1,485,500
Planting to produce commercial timber	3,511,459

To meet this need it has been necessary to experiment carefully in order to determine the best methods and species to use. Attention has been paid, first, to city watersheds, and eight nurseries have been established within a period of five years, having a capacity of approximately 5,000,000 trees. Not all of these have trees old enough to plant, but there are now 2,250,000 trees ready for planting, and this figure will increase annually. Two of these nurseries provide trees for planting in the sand hills of Nebraska and Kansas. This planting is to serve as an object lesson to the people and to provide useful material in the future for this region. The others provide trees for watershed planting to improve the condition of water supply in Colorado, Idaho, Utah, California, and New Mexico.

In addition to planting trees, experiments were begun recently to determine the practicability of seed sowing on the sites where a new forest is desired. Less than a ton of seed was used in 1907 in a series of experiments on 27 forests in 8 States. In 1908 over 6 tons of seed were secured to extend this work materially. Success has been obtained by this method in reforesting burned areas of yellow pine in the Black Hills National Forest. It seems likely that reforestation by seeding will be largely successful in northern forests and at high altitudes where moisture is more abundant. Planting will be absolutely necessary on the drier situations having less brush and grass cover, and especially in the southern forests.

All sowing and planting work is planned ahead for a five-year period and preceded by a careful study of the forest.

Only 1,762 acres have been forested since the work began, but this area represents many situations and conditions, and valuable data have been secured bearing on future work. In addition to this great task of reforesting 5,000,000 acres of denuded land, planting and sowing will be necessary to supplement natural reproduction in the forest, and will become a regular part of forest management in national forest work.

CONCLUSION.

Just as the greater portion of the forest area of the United States lies in the East, so the amount of land requiring restocking with forest is greater in that region. Conservative lumbering and forest planting within national forests and by private owners in the West

30-YEAR-OLD GROVE OF MANNA GUM (EUCALYPTUS) IN SUTTER COUNTY, CAL.

3-YEAR-OLD BLACK LOCUST PLANTATION ON IRRIGATED LAND, IDAHO.

will maintain a permanent supply of our valuable western conifers, but in the East the perpetuation of the best species of hard woods and conifers is dependent largely upon the activity of the private landowner. It is essential that the people of each State should realize the immense importance of individual effort in providing for a future timber supply and not depend wholly upon the results of federal or state action. The amount of land that can be restored to value through planting by the Federal Government or the States is small compared to the great area that must be forested eventually by private landowners or corporations.

TABLE 1.—*Eastern region—Northern forest.*

States.	Total area.	Area that should be planted by state governments.	Area that should be planted by United States Government.	Area of private lands that should be planted.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Maine	19,132,800			181,300
New Hampshire	5,779,840			558,400
Vermont	5,839,360			444,000
Massachusetts	5,144,960			532,200
Rhode Island	682,880			50,000
Connecticut	3,084,800			500,000
New York	30,498,560	45,000		1,523,800
Pennsylvania	28,692,480	76,000		1,232,400
Michigan	36,787,200	400,000		5,000,000
Wisconsin	35,363,840	200,000		4,682,200
Minnesota[a]	25,874,560	800,000	10,000	1,617,979
Total	196,881,280	1,521,000	10,000	16,322,279

States.	Total area requiring planting.	Area of past planting by state governments.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899-1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Maine	181,300		228	743.56
New Hampshire	558,400		865	164
Vermont	444,000		1,015	678.2
Massachusetts	532,200	1,463	21,463	1,939.5
Rhode Island	50,000		300	306.28
Connecticut	500,000	226	1,340	1,022.125
New York	1,568,800	3,450	4,450	9,150.8
Pennsylvania	1,308,400	100	4,435	5,575.24
Michigan	5,400,000		3,500	14,378
Wisconsin	4,882,200		500	656
Minnesota[a]	2,427,979	250	5,250	140
Total	17,853,279	5,489	43,346	34,753.705

[a] Fifty per cent of the State is considered in forest, and figures are based on this estimate.

TABLE 2.—*Eastern region—Central hard-wood forest.*

States.	Total area.	Total area that should be planted.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899-1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*
New Jersey	4,808,960	308,400	185	45
Delaware	1,257,600	12,450	....	....
Maryland and District of Columbia	6,400,640	20,100	5,000	606
Virginia	25,767,680	1,310,450	380	227.35
West Virginia	15,374,080	2,745,150	400	480
Ohio	26,073,600	627,350	13,000	481.6
Indiana	22,966,400	580,900	10,000	1,141
Kentucky	25,715,840	1,009,000	1,500	134
Tennessee	26,679,680	1,900,000	200	....
Missouri	43,985,280	1,437,800	2,400	91.5
Arkansas	33,616,000	940,500	500	100
Oklahoma[a]	33,318,720	640,500	8,000	200
Total	265,964,480	11,532,000	41,565	3,506.45

[a] That portion of the State east of the ninety-ninth meridian.

TABLE 3.—*Eastern region—Southern forest.*

States.	Total area.	Total area that should be planted.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899-1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*
North Carolina	31,193,600	927,900	3,100	387
South Carolina	19,516,800	320,490	....	100
Georgia	37,584,000	623,760	....	....
Florida	35,111,040	1,175,070	150	3,000
Alabama	32,818,560	969,900	2,500	740
Mississippi	29,671,680	302,460	100	....
Louisiana	29,061,760	140,370	2,200	....
Texas	83,967,360	602,250	150	200
Total	298,924,800	5,152,200	8,200	4,427

TABLE 4.—*Central treeless region.*

States.	Total area.	Area of future planting required east of ninety-ninth meridian.	Area of future planting required west of ninety-ninth meridian.	Area of future planting required on national forests.	Area of irrigated land requiring planting.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Illinois	35,841,280	....	....	....	....
Iowa	35,575,040	....	....	....	....
Minnesota [a]	25,874,560	....	....	....	....
North Dakota	44,917,120	694,463	881,260	....	2,280
South Dakota	49,195,520	713,033	922,205	150,000	3,000
Nebraska	49,157,120	612,144	924,687	556,072	900
Kansas	52,335,360	784,941	876,285	302,387	240
Oklahoma [b]	11,106,240	....	312,044	5,000	....
Texas [b]	83,967,360	....	2,505,851	....	1,800
Total	387,469,600	2,804,581	6,422,332	1,013,459	8,220

States.	Total area that should be planted.	Area of past planting east of ninety-ninth meridian.	Area of past planting west of ninety-ninth meridian.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899-1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Illinois	1,456,526	....	....	15,568	198.58
Iowa	1,929,752	....	....	125,000	170.9
Minnesota [a]	1,178,728	....	....	115,000	218
North Dakota	1,578,003	34,937	17,093	52,030	257.62
South Dakota	1,788,238	110,462	11,563	122,025	864.53
Nebraska	2,093,803	133,541	58,455	191,996	320.99
Kansas	1,963,853	154,131	20,892	175,023	1,105
Oklahoma [b]	317,044	....	21,143	21,143	627.675
Texas [b]	2,507,651	....	13,169	13,169	1,724.86
Total	14,813,598	433,071	142,315	830,954	5,488.155

[a] Prairie portion of the State considered to be 50 per cent.
[b] That portion west of the ninety-ninth meridian.

TABLE 5.—*Western region.*

States.	Total area.	Total cut-over land not restocking in national forests.	Total cut-over land on military reservations.	Total cut-over land that should be planted by private persons.	Total area of forest land requiring planting.
	Acres.	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Montana	93,296,640	434,000	....	....	434,000
Wyoming	62,460,160	637,000	6,892	....	643,892
Colorado	66,341,120	932,500	....	27,793	960,293
New Mexico	78,401,920	226,000	2,564	....	228,564
Arizona	72,857,600	255,000	....	5,000	260,000
Utah	52,597,760	174,000	....	16,976	190,976
Nevada	70,285,440	....	....	....	....
Idaho	53,618,560	228,000	....	....	228,000
Washington	42,775,040	103,500	1,050	53,760	158,310
Oregon	61,188,480	150,000	150	89,273	239,423
California	99,898,880	1,113,500	....	83,838	1,197,338
Total	753,721,600	4,253,500	10,656	276,640	4,540,796

TABLE 5.—*Western region*—Continued.

States.	Total area of treeless land to be planted.	Total area that should be planted.	Total area of past planting.	Area of planting plans prepared by Forest Service, 1899-1908.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Montana	358,513	792,513	500	600.6
Wyoming	249,136	893,028	1,000	
Colorado	262,144	1,222,437	8,000	63.3
New Mexico	158,126	386,690	3,000	5,806.55
Arizona	60,859	320,859	500	
Utah	107,432	298,408	1,000	50
Nevada	81,769	81,769	100	.5
Idaho	103,947	331,947	1,000	
Washington	208,978	362,288	500	90
Oregon	215,206	454,629	1,500	503
California	785,230	1,982,568	20,000	8,664.95
Total	2,586,340	7,127,136	37,100	15,778.9
Total on national forest			1,762	
Grand total			38,862	

TABLE 6.—*Summary.*

Region.	Total area.	Total area that should be planted.	Total area of past planting.	Number of planting plans prepared by Forest Service, 1899-1908.	Area of planting plans.	Area reported planted under advice of Forest Service.[a]
	Acres.	*Acres.*	*Acres.*		*Acres.*	*Acres.*
Eastern region, northern forest	196,881,280	17,853,279	43,346	101	34,753.705	2,672
Central hard-wood forest	265,964,480	11,532,600	41,565	65	3,506.45	458.5
Southern forest	298,924,800	5,152,200	8,200	15	4,427	173.5
Total, eastern region	761,770,560	34,538,079	93,111	181	42,687.155	3,304
Central treeless region	387,969,600	14,813,598	830,954	223	5,488.155	1,071.5
Western region	753,721,600	7,127,136	38,862	48	15,778.9	469
Grand total	1,903,461,760	56,478,813	962,927	452	63,954.21	4,844.5

[a] Actual areas planted up to July 1, 1908, according to reports by 45 per cent of the persons who were given advice and assistance.

WATER CIRCULATION AND ITS CONTROL.

By Bailey Willis, E. M. C. E.,
United States Geological Survey.

CIRCULATION OF WATERS.

The moisture which falls upon North America in the form of rain and snow comes chiefly from the Pacific Ocean. A smaller proportion rising from the Gulf of Mexico and the West Indian seas falls upon the eastern United States. A part of this precipitation returns to the air; another part flows to the streams; a third enters the ground. It all sooner or later returns to the oceans. In this great general circulation there are many short cuts and many stop-overs. Rain which falls upon the sea has taken a short cut. Snow which gathers in banks and glaciers, water which lingers in lakes, swamps, and especially in the soil and deeper recesses of rocks underground, has stopped over for a longer or shorter time. On the whole, the great body of moisture moves constantly, circulates in various forms through the air, on the earth, and through all parts of the superficial crust of the earth, and in its constant flow is the most vital element affecting the life of plants and animals. The very air itself is not more necessary than the presence of an adequate and fairly regular supply of moisture.

These vast movements of moisture transcend our control, but their effects do not. Has not man through intelligent skill converted the desert into a garden? And has he not through obstinate ignorance turned the garden into a desert? The path of our race from Asia across Europe has led through many such gardens; it is marked also by such deserts.

Says Irving in the charming introduction to The Alhambra:

> Though there are exceptions in some of the maritime provinces, yet for the greater part Spain is a stern, melancholy country, with rugged mountains and long sweeping plains destitute of trees and indescribably silent and lonesome, partaking of the savage and solitary character of Africa. What adds to this silence and loneliness is the absence of singing birds, a natural consequence of the want of groves and hedges. The vulture and the eagle are seen wheeling about the mountain cliffs and soaring over the plains, and groups of shy bustards stalk about the heaths; but the myriads of smaller birds which animate the whole face of other countries are met with in but few provinces in Spain, and in those chiefly among the orchards and gardens which surround the habitations of man.

No better description could be written, not only of Spain but of Asia Minor, where the marbles of Grecian civilization mark the sites of lost cities; or of Dalmatia, where barren plateaus have replaced the forests from which Rome built her navies; or of many other parts of southern Europe and northern Africa, where man has helped to rob nature of her charm and transformed her gentleness into stern severity.

We Americans have left these desert mountains behind in Eurasia; but we occupy the last land that lies toward the setting sun. Our children and our children's children for countless generations are to enjoy the gardens or bewail the deserts we create.

In the general circulation there is just one point where agencies under human control can directly affect the course of the movement. It is where rain strikes the ground or the vegetation covering the ground. From this point three routes are open to the moisture. It may evaporate, it may run off, or it may sink in. That which evaporates is lost to man's immediate use; that which runs off may be useful, but is frequently so violent as to be harmful; that which sinks in flows slowly to the springs and streams and becomes available when most needed.

Now man can send more water back at once to the air and down to the streams, or he can lead a larger proportion into the soil to enrich his crops, to feed springs, and to bear his boats during low river stages, or he can strip the ribbed rocks of soil, as witness Spain, France, Italy, Greece, and China, or he can clothe the surface with forest or verdure or thirsty fallow.

It is the object of this paper to consider the methods and efficiency of man's control, through engineering, agriculture, and forests. But before entering upon that subject we may take a general view of moisture in circulation along the several parts of the route that are commonly known as precipitation, ground water, evaporation, and surface flow.

PRECIPITATION.

Air and moistre may be mixed, as in clouds and mists, and some amount of moisture is dissolved in the air, no matter how dry it may seem. These two states of moisture in the air, whether mixed or dissolved, depend chiefly on the temperature. Changes of temperature are related to changes of barometer, and pressure has an effect on the condition. For any particular temperature and pressure the air will hold a certain amount of dissolved moisture and no more.[a]

Any effect which changes the temperature of the air makes it either more or less thirsty. A familiar instance is the cloud banner which seems nailed to a mountain top, especially to a snow peak, in spite of a strong wind. In that case a warm air current containing dissolved moisture is cooled by rising along the slope or by contact with the snow, and a part of the moisture becoming condensed is seen as a cloud. Blown further, the water particles are redissolved in warm air currents and the cloud ends; but as the conditions and changes are continuous the banner is not blown away.

A similar phenomenon may be observed over such regions as our great plains, where the column of rising air, becoming dilated and cooled, forms a rain cloud at great height, yet the falling rain is dissolved in the hot air below before it can reach the ground. No one who has seen the shower vanish into thin air will question the effectiveness of radiation from treeless plains under a summer sun to prevent precipitation.

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[a] Dissolved here means invisibly dispersed in the air. The physical or chemical nature of solution is not in point.

Who does not know a drying wind? Such an one as blows cold from the Canadian snows and warming up drinks up moisture from every pore of the surface? Or if you have crossed the Cascade Mountains of Oregon or Washington you know how the wet air of the western ranges contrasts with the furnace dryness of the eastern plains. The mountains are wet because they are high, and they are heavily forested because they are wet. But there is also a reciprocal action of the forests on the wetness, for the radiation from the dark green expanse is comparatively uniform and promotes frequent and steady rains. Were the mountains bare they would, like the bared sierras of Spain, receive occasional but violent downpours and send down excessive and disastrous floods, even more disastrous than now.

On the other hand, the plains are dry because they are low and situated beyond the heights in the path of moisture-bearing currents, and they are without forests because they are dry. But here also there might be, yes, may be, a reciprocal action of vegetation on the dryness. For in so far as we clothe the surface with green crops we lower the temperature of the rising air and favor precipitation on the verdure covered plain.

Thus moisture, in pursuing the great globe-encircling routes of the winds, may be influenced by local conditions to stop or to hasten on. There is a cycle of reactions which begins with rain, is continued by ground water and vegetation, and leads back to rain. The showers sink in, the seed germinates, the plant grows in the moist soil, and the cool, moist air above the green surface provokes a shower; or the downpour dashes off, the bare surface radiates the heat of the brilliant sun, and the shower that might fall passes over.

These reactions are not the great ones, but they are effective enough in many regions to make a garden or a desert, as the experience of our race, viewed in the light of modern knowledge, proves.

GROUND WATER.

If anywhere in humid regions a well be sunk deep enough water will commonly be found. The water fills the soil or the spaces in the rocks. It flows into any opening and is governed by gravity, so that it runs down grade under ground. It is "ground water" and its surface is the "ground-water table."

In humid regions the ground-water table corresponds with the surface level of swamps and streams in their immediate vicinity, but it rises above them in uplands, following in a measure the altitude of the surface, though it does not reach an equal height. From the higher parts the ground water flows down to the lower; that is, from the uplands underground to the streams. If it be replenished by frequent rains it feeds the streams steadily. If not, the supply diminishes at first rapidly and then very slowly. It is the principal source of moderate and low-water flow in rivers of the eastern United States.

In arid regions the ground-water table usually lies at considerable depth or is wanting. Underground water may even be restricted to deep water-bearing strata, which it enters along the outcrop and in which it is under artesian head.

In all regions, except excessively dry deserts, the soil above the ground-water table contains some moisture, which envelopes the grains with a thin film only, if the soil be very dry, but which otherwise occupies the minute spaces between the grains. This moisture does not fall or rise in obedience to gravitation, it being under control of forces due to surface tension, which exist in tubes of very small bore (capillary tubes) and similar minute spaces. These forces of surface tension, overpowering the effect of gravitation, draw the moisture upward or sideways or downward in the direction of least moisture and thus tend to establish a balance throughout the mass so far as the capillary films are continuous. If there be evaporation from the surface the moisture is drawn upward, and this is the principal effect due to capillary attraction.

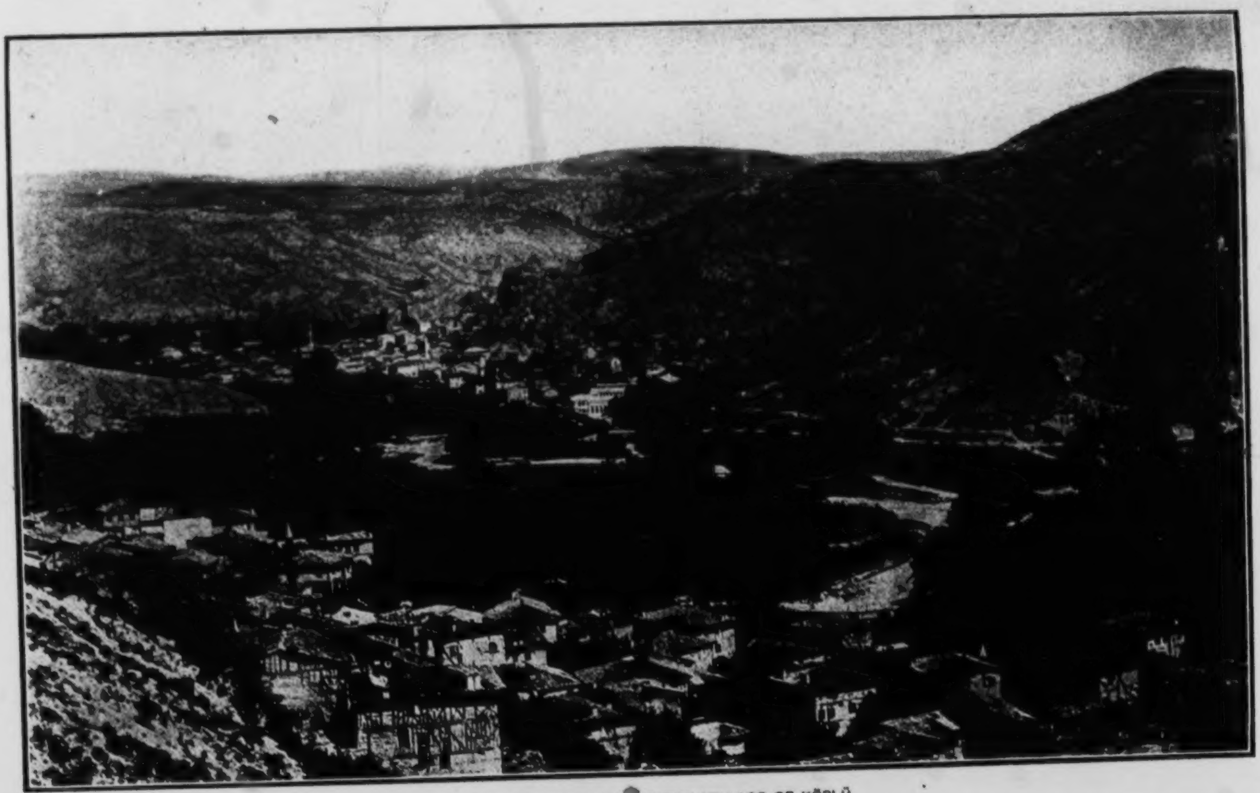
In humid regions the ground water and the soil moisture are in contact. From the surface of the ground to the water table the soil is more or less moist, and if evaporation takes place the upward movement may extend down to the water table, and some part of the ground water may be drawn into the capillary circulation.

In arid regions the ground water and soil moisture are commonly not connected, but are separated by a greater or less space in which the capillary films that envelope the soil grains are not in contact and there is consequently no capillary circulation. This is true under much of the great plains. Streams are there fed only by immediate flood run-off or by underground waters from remote mountains.

Both ground water and soil moisture are derived from precipitation; the soil moisture in any area being part of the rain or snow that falls on that area; and ground water also being often accumlated from the surface which it underlies, but frequently coming from higher grounds near by or sometimes far away. This fact places in the farmers' hands the power to regulate the most vital thing in making a crop, by seeing to it that rain goes into the soil and not over it or away with it.

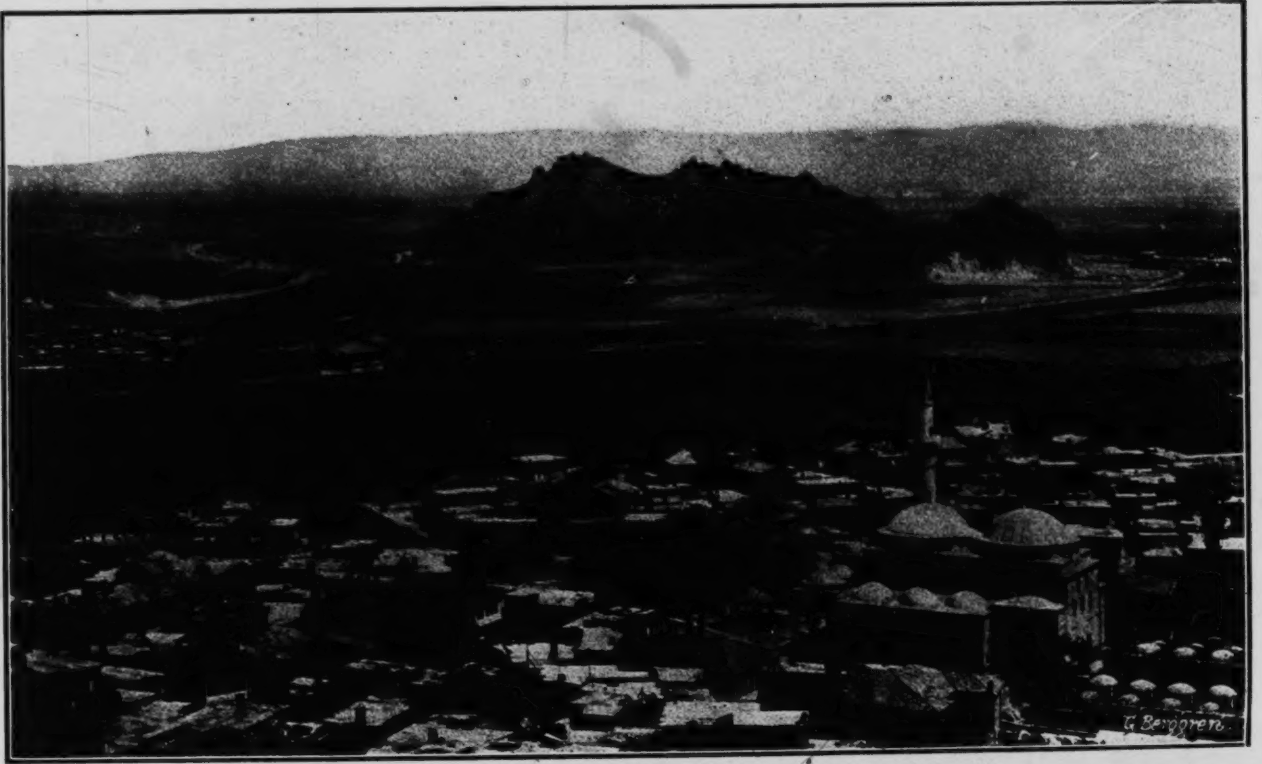
EVAPORATION.

When dry air passes over a moist surface it absorbs moisture from the latter. This is the simple process of evaporation, which is, however, subject to intricate relations of temperature, pressure, and humidity. Considering it as a way in which water that we want in the ground escapes into the air, we are interested to limit evaporation. This is possible by keeping the surface cool and the air above it moist, as under trees; and in sufficiently arid regions it is accomplished by covering the surface with a dry mulch, which cuts off the upward rise of moisture. The action of the woods in keeping the air and ground cool and moist is not open to question; even on the semiarid plains a wind break notably reduces evaporation from the fields in its lee; but it is held by some writers that the trees draw in through their roots and transpire through their leaves more moisture than would evaporate were the soil beneath them bare. This is true with regard to the soil reached by their roots, particularly on plains. On hill slopes it is also true, but trees so increase the amount of water stored in sloping ground, over that which can be stored in the same slope if bare, that they more than make up for what they transpire.



NO. 1.—ASIA MINOR. VIEW OF THE VILLAGE OF KÖPLÜ.

One hundred and thirty kilometers southeast of Constantinople, showing the deforested and completely denuded mountains. Note the areas of attempted reforestation indicated by spots in which shrubs are regularly spaced. (Photo by G. Berggren.)



NO. 2.—ASIA MINOR. VIEW OF THE CITY OF AFIUN KARA-HISSA.

Situated about 200 miles southeast of Constantinople, in the valley of the Akkar, at an altitude of 3,300 feet (1,007 meters) above sea, showing the rocky cores of hills which have been completely denuded of vegetation and soil. (Photo by G. Berggren.)

In regard to the manner of evaporation from soils under arid and humid conditions we may best quote as follows from Buckingham:[a]

> When a moist soil dries by contact with the air above it the loss of water takes place by evaporation close to the surface, the amount lost by direct evaporation from points several inches below the surface being in general negligible. As the surface soil dries out a moisture gradient is established, and the dry surface soil draws up water from the moister region below by capillary action. If this capillary flow of water be prevented or lessened, as by the use of a mulch, the escape of water is decreased, because the evaporation has, on the whole, to take place from farther below the surface, so that it encounters greater resistance and is slower.
>
> The flow of water in a soil which is not very wet has to take place through the thin films in which a part of the water is distributed over the soil grains. If the soil becomes very dry it is to be expected that these films will become thinner or break, the resistance to capillary flow increasing very much in either case. Hence it is to be expected that in very dry soils capillary flow will be slow.
>
> Suppose a soil could be made so dry that no capillary flow at all would take place in it even when it was in contact with a moist soil. Such a layer of soil would act toward the moist soil below it as a protecting mulch. A soil can probably not be made so dry as to lose its power of capillary conduction of water entirely, but we may get an approximation to this limiting case.
>
> Suppose that after a rain the soil surface be exposed to very arid conditions with a high surface temperature and a hot, dry wind. The surface of the soil will lose water much faster than it can be brought up from below by capillary action, and if the arid conditions be kept up a layer of dry soil will be formed on the surface, which may be so dry as to act in the manner suggested, i. e., as a protecting mulch. We shall thus have an initial period of very rapid evaporation, followed by a period of slow evaporation, taking place largely from below the surface.
>
> If the same soil had been subject to less arid conditions the initial loss would have been less. The capillary flow from below would have been sufficient to prevent the surface soil from becoming dry enough to act as a mulch; hence, though the initial rate of loss would be smaller, that rate would not fall off so rapidly. It might even happen that in the long run the soil under the arid conditions would actually lose less water than the same soil under humid conditions.

From these statements and the careful experiments on which they are based it appears that in humid regions evaporation from a bare surface is not readily controlled, whereas in arid regions the precious moisture may be retained by a mulch of sufficiently dry soil.

SURFACE FLOW.

Surface flow is the water in swamps, lakes, and streams. It is all derived from precipitation, but is gathered from the surface in part only; another part appearing from seepages and springs after a trip underground. The former we will call "flood run-off," the latter "seepage run-off."

Flood run-off is that part of rain or snow fall which remains on or very near the surface, flows directly to swamps, lakes, or streams, and immediately or in a short time runs away. Following showers, flood run-off raises streams; following prolonged rains or melting snow it occasions high water, which quickly recedes when the rain or melting ceases; and following excessive rains or melting, flood run-off produces great floods.

Flood run-off is thus the most transient, irregular, wasteful, and dangerous part of precipitation.

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[a] Buckingham, Edgar: Studies in the movement of Soil Moisture. U. S. Dept. of Agriculture, Bureau of Soils, Bull. No. 38, pp. 18–19, 1907.

It damaged the people in the United States in eight months, January 1 to August 31, 1908, to the extent of $237,000,000. In the year 1907 it occasioned the loss of $118,238,000. In the ten years prior to December, 1906, it cost not less than $1,500,000,000 in goods, buildings, bridges, roads, railroads, and real estate, washed away.

These losses are net losses; they do not include deterioration of values not actually destroyed, nor do they cover the incalculable, irreparable loss of fertile soil from our mountains, grazing lands, and fields. This loss amounts to approximately 1,000,000,000 tons of soil per annum. Nor does the financial loss include the sum of human suffering or the loss to the nation through lowered efficiency and morale of the citizens who suffer from floods.

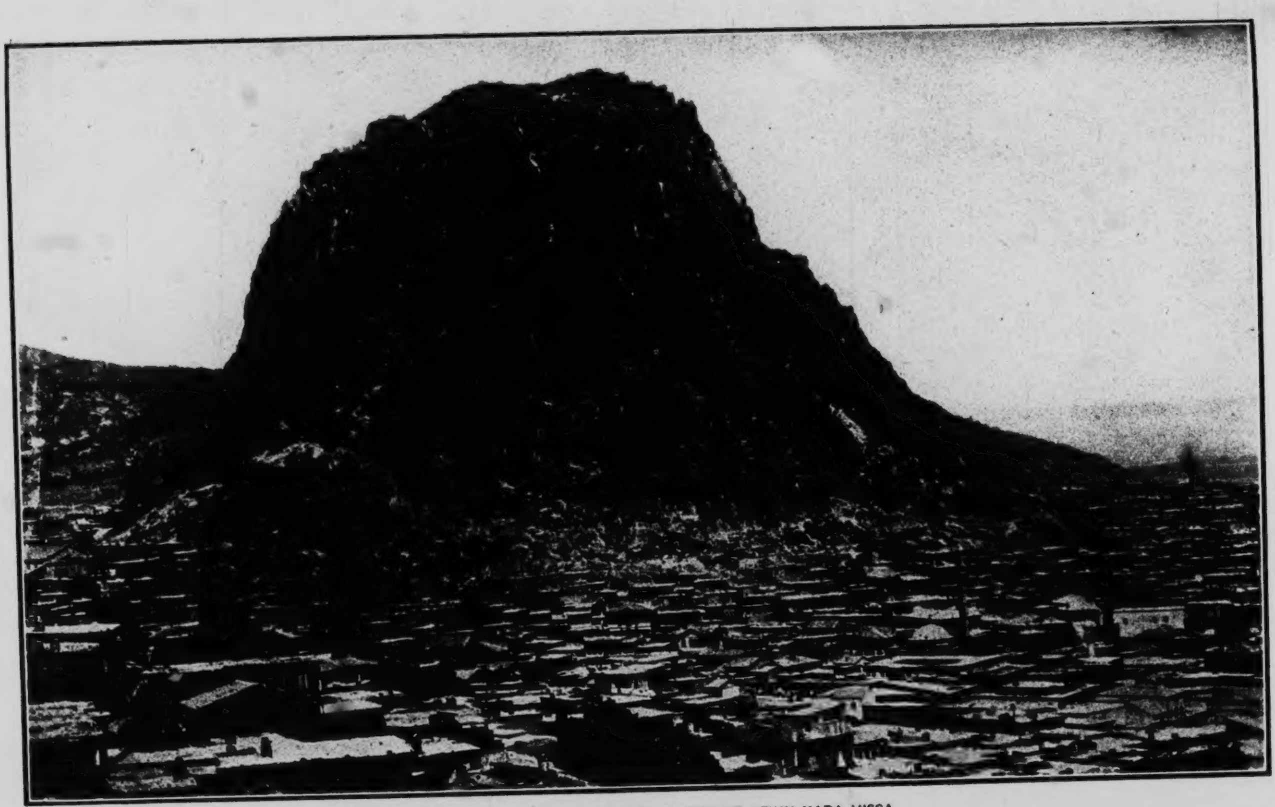
Seepage run-off stands in direct contrast to flood run-off. It is slow and gradual where the other is quick and spasmodic; it is regular where the other is irregular; it continues when the other fails. The uses of surface waters (crop growing, city water supply, sanitation, water power, and navigation) depend on reliability and regularity. Hence it is obvious that the works of man should be designed to increase that part of rainfall and snowfall which, sinking into the ground, contributes to seepage run-off, and to regulate the flow of that considerable part which can not enter the ground.

Rain falling on a well-tilled field or grass or forest largely sinks in. Falling on bare, baked, incrusted ground, it dashes off. Whichever in any place occurs, some farmer or herdsman or lumberman is responsible, for there is now no considerable part of the United States that man does not make or mar. But at the best there will always remain a notable proportion of precipitation that will form flood run-off, and this we must commit to the care of the engineer as part of the surface flow which it is his duty to control.

OUTLINE OF METHODS OF CONTROL.

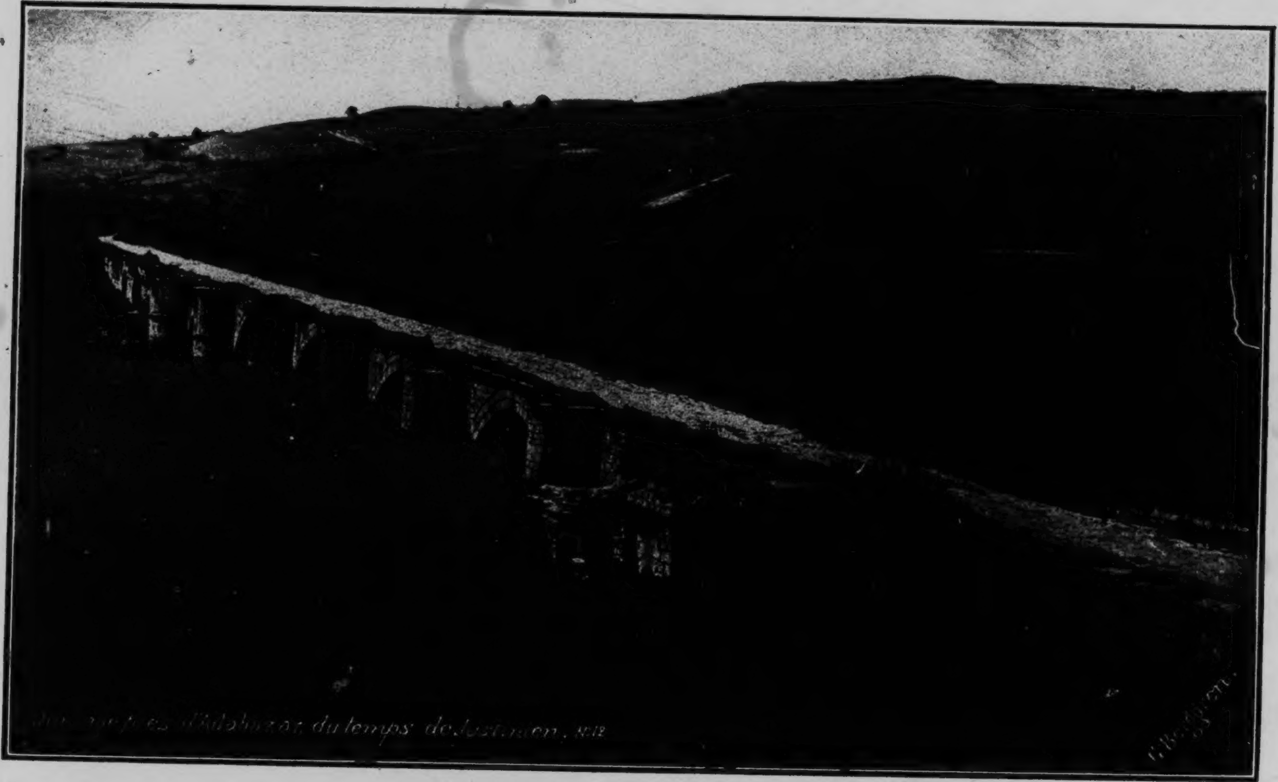
ENGINEERING CONTROL OF SURFACE FLOW.

The engineer aims to regulate surface flow through methods of storage, diversion, or confinement in an established channel. His selection of method is determined by the topographic conditions of the particular locality primarily, and also by the balancing conditions of need and cost. The result is a reservoir, canal, or other structure designed to be permanent, to meet the greatest emergency which may arise, and to supply such water or afford such relief from water as conditions require. When practicable the investment should return to the people at least a fair interest on the cost. These limiting conditions are so well understood and engineering practice is based upon such a thorough knowledge of fundamental mechanical principles that in any given case the engineer's calculation may be implicitly trusted, provided that the factors of run-off, fluctuation, and sediment, which are fundamental elements of the problem, do not at any future time exceed the maximum limits which past experience leads him to assume. This provision implies that the progress of settlement and the exploitation of our natural resources should not unfavorably modify the relation of run-off to ground storage and evaporation. Through ignorance, carelessness, and greed, the farmer, herdsman, and lumberman are constantly violating this provision, as we



NO. 3.—ASIA MINOR. VIEW OF THE CITY OF AFIUN KARA-HISSA.

Showing the old citadel crowned by ruins. The mountain is a residual mass of volcanic rock from which all overlying strata and soil have been removed by erosion. (Photo by G. Berggren.)


près d'Adabazar du temps de Justinien, 1212
G. Berggren

NO. 4.—ASIA MINOR. ADABAZAR.

One hundred and twenty kilometers east by south of Constantinople, a short distance south of the Black Sea, showing a bridge built by the Romans in the time of Justinian over a stream whose bed is now cultivated as a field. (Photo by G. Berggren.)

shall see when we come to the consideration of the specific relation of their activities to the partition and distribution of precipitation. The engineer is now called upon to regulate run-off, the irregularity of which is persistently aggravated by these widespread activities; he is required to take care of sediment whose volume is constantly increased by vicious methods of agriculture, grazing, and deforestation, and the nation collectively spends millions on engineering while the people individually render the expenditure useless.

The engineer urgently needs the support of an educated, enlightened public opinion which will control individuals. In proportion as every landowner manages his property intelligently with regard to its perpetual value and the welfare of the commonwealth, the engineer's problem will shrink within those limits of reasonable magnitude and cost which it now threatens to exceed.

Let us consider some examples of the engineer's methods of regulating surface flow by storage, drainage, diversion, and canalization.

The construction of reservoirs for the storage of waters is in comparison with its possibilities very slightly developed in the United States. A few examples will illustrate the magnitude and purposes of existing works.

The Croton reservoir system cost Greater New York $86,359,562 up to 1898, and estimates on extensions and improvements are $161,000,000. The city can afford it, for the system supplies pure water to 4,000,000 persons, among whom, considering one benefit only, the death rate from typhoid fever was, in 1905, 16 per 100,000, as against more than 100 per 100,000 in certain cities supplied with polluted river water.

On the upper Mississippi a reservoir system has been gradually installed since 1880 to control high and low stages of the river for navigation. Lake levels were raised and low, flat lands were flooded. The topographic conditions were favorable and the cost for lands and improvements submerged was low. In sixteen years the Federal Government expended $1,525,000.[a]

Storage reservoirs for irrigation waters were established in the arid West by private enterprise in the early settlement of the regions, but work on a large scale began after the passage of the reclamation act, in 1902. The Reclamation Service has 28 projects in various stages of progress. They will make available for homes 1,910,000 acres, at a cost of $70,000,000, or $36.65 per acre.[b]

In any particular case the cost per acre-foot of storage capacity depends chiefly on the topographic situation, which determines the magnitude and character of the structures, and on the value of property to be displaced or submerged. In general, it costs less per acre-foot to store a large body of water than a smaller one.

The efficiency of a reservoir may be said to be its capacity to retain the water which ought to be stored. If it will hold all the surface flow of its drainage basin, less the amount used and evaporated during any time, its efficiency is 100 per cent. In proportion as it fails to do this during floods its efficiency falls below the maximum. A reservoir which will have an efficiency of 100 per cent is being built by the Reclamation Service on the Rio Grande above El Paso. It will retain more than the entire annual precipitation, approximately three times the surface flow of the drainage basin, and when it is completed floods which have been disastrous will be absolutely abolished.

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[a] Annual Report, Chief of Engineers, U. S. Army, part 2, p. 1439, 1906.

[b] Blanchard, C. J.: Home-Making by the Government. Nat. Geogr. Mag., April, 1908.

If other conditions are alike, the efficiency depends on the amount and distribution of the waters from rain and snow melting. These vary according to broad districts. The factor which primarily determines cost, namely, the character of topographic basins which may be dammed, also varies broadly, and according to the distribution of these two factors we may distinguish at least four regions which are unlike in regard to storage possibilities.

The arid plains and basins of the West afford conditions of minimum or moderate cost and maximum efficiency for reservoir storage. The experience of the Reclamation Service has been cited.

Another region where reservoirs of moderate cost and adequate efficiency are possible is that of lakes and swamps which lie within the area covered in a recent geologic epoch by the great ice sheet. It includes parts of the Dakotas, Minnesota, Wisconsin, Illinois, Indiana, Michigan, and, in a less degree, New York and New England. In this region there are thousands of lakes, each one of which is a natural reservoir, and many more swamps, each one of which is a shallow, but practicable, reservoir site. The experience with the government dams on the upper Mississippi gives the best insight into the value of these reservoir conditions.

A third district which may be distinguished with reference to the possibilities of reservoir storage is found in the prairie States—Iowa, Illinois, and Ohio—and in areas of similar topography, population, and precipitation. In that part of those States which lies outside of the old ice limit, streams as a rule run in ravines or narrow valleys, which, however, have moderate fall and would, in many localities, afford practicable conditions for reservoir storage. The cost of farm lands and town sites which must be submerged is such, however, as to render capacious reservoirs too costly, provided any other means of control be practicable. Here the question of cost will limit the construction of large reservoirs. The lands are farmed and upon the farmer must rest the responsibility to the nation for a proper regulation of the water flow. The topographic character of the region is favorable to the construction of large numbers of small reservoirs to catch the flood run-off from nearby fields, and this item in farm equipment should become as much a matter of public interest and control as the maintenance of public roads. But the silt from badly tilled fields will render reservoirs useless unless the farmer prevents erosion. The larger factor in control must be found in improved methods of tillage and crop rotation.

A fourth district which presents special conditions in regard to storage is that of the Appalachian Mountain region. Here topographic forms are such as to render reservoir construction both difficult and expensive. The narrow valleys alone offer possible sites. Their steep gradients necessitate high dams for reservoirs of moderate capacity. Where wide bottom lands afford better opportunities, important towns are commonly located. Moreover the efficiency of such reservoirs must be low, because the flood run-off is torrential and some considerable part of it must be permitted to escape. We may not, however, conclude that reservoirs are impracticable.

NO. 5.—VIEW AT THE IRON GATE ON THE DANUBE IN SOUTHEASTERN AUSTRIA.

Overlooking a portion of the Transylvanian Alps, which are maintained under forest cover except on gentle slopes. There is striking resemblance in topographic forms and physical conditions to those of the Appalachian Mountains south of Pennsylvania. (Photo by B. W.)

NO. 6.—AUSTRIA. VIEW IN THE NORTHERN CARPATHIANS NEAR NEU SANDEC, ON THE HEADWATERS OF THE DUNAJEC, AT AN ALTITUDE OF ABOUT 3,000 FEET.

A region in which forests have been properly cared for and exploited, and in which the slopes are carefully protected by covering of forest or grass with proper attention to methods of culture that prevent erosion. The field on the left is being cultivated. It may be noted that the furrows are all strictly horizontal. (Photo by B. W.)

The Appalachian Mountains have always had and will always have special relations to national development. Their mountain wall guarded the colonies during a century of French and Indian warfare. Eventually occupied by American enterprise, the region became through its resources in minerals, lumber, and water power a dominant source of national strength and wealth. It can never support a large agricultural population, yet the mountain dwellers will cultivate their fields in its upland valleys so long as the soil remains. Its mineral wealth will certainly be exhausted, but its forests and streams, those two intimately related and most valuable factors in the nation's prosperity, need never be impaired though continually used.

These mountains possess a power to do harm which is not less than their power to confer benefit. The floods that gather from their rills traverse the richest cities, manufacturing districts, and valleys, and exact annually an enormous tribute. The cost in dead loss, in lessened values, and crippled industries will eventually force the nation to protect itself. There are men—engineers, too—who believe they can fetter the full-grown flood, but the Commonwealth which trusts to them alone and neglects the agencies of forestry and agriculture that divert the raindrops will suffer till it has bought wisdom dearly.

Thus throughout this mountain region the problem of controlling surface waters is not only particularly difficult, but its solution is peculiarly important. The engineer has here a grave and difficult task to perform, and even under the unfavorable local conditions the storage reservoir must take its place as one of the features of the system of regulation.

In our general discussion drainage is next. It stands in direct contrast to storage. It promotes quick discharge, increases flood run-off, and dries up swamps that storage would convert into reservoirs. No region from which injurious floods gather should be drained, for the drainage system will increase the floods. On the upper Mississippi, for instance, we would not drain the reservoirs produced by artificial dams, nor should we drain swamps that empty into them or into the river below them without duly considering to what extent our left hand is undoing the work that our right hand has done.

Yet drainage has its place in the national management of surface waters. It is appropriate in lands liable to overflow and which may safely be permitted to return the waters promptly to the stream as the river falls. It is permissible in lands whose value when drained exceeds the value of lands that the drainage waters may submerge. Here, as indeed generally, throughout this whole question of conservation the resulting value determines whether or no the thing should be done.

Diversion canals are designed to take a part or all the water of any system and conduct it from the channel in which it may be wasted or become harmful to the point where it shall be applied to some useful purpose. A mill race is a diversion canal on a small scale, and the Chesapeake and Ohio Canal, which diverts a part of the waters of the Potomac to a channel where they may be useful to navigation, falls in a similar class. In connection with the irrigation projects of the Reclamation Service, diversion canals constitute an important feature. In some instances they lead directly from rivers which are capable of furnishing sufficient water at all stages; in other instances, they lead from reservoirs where water is stored to maintain the desired flow when the tributary streams would be inadequate to the purpose. In none of these cases has the diversion canal any special relation to the conservation of water. It introduces a siding in the general through route of circulation and discharges its water freight at the point where it is wanted. It serves in some measure to regulate surface flow, but that object is subsidiary to a major purpose, which may be power or irrigation or navigation.

Canalization is a method of river control which consists in reducing the river to the condition of a canal by the introduction of dams, locks, and sluice gates. The current of the open river is then replaced by slack water. The discharge is permitted through locks as required by passing boats, or over sluiceways when the volume of flood run-off becomes greater than the amount which can be safely stored in any reach of the river between dams. The most important project for canalization is that of the Ohio River, concerning which we may quote from the report of a board of army engineers, dated December 15, 1906.[a]

The board finds—

> that a 6-foot navigation at low water can be established in the Ohio River from Pittsburg to Cairo by the construction of 45 locks with movable dams, at an estimated cost of $50,962,266, in addition to funds heretofore appropriated and authorized; that a 9-foot navigation over the same length of river can be established by the construction of 54 locks and dams, at an estimated cost of $63,731,488. * * *
>
> The board gives exhaustive consideration to the question of present and probable commerce, both down stream and up, and it appears that the present commerce of the river is approximately 9,000,000 tons per annum, of which a large proportion is downstream. Having in view the fact that a canalized river offers an upstream navigation lower in cost and quicker in transit than an open-river project, the board, arguing from the known natural resources of the section and its population, concludes that a river improved by this method will afford facilities for the cheap exchange of mineral, agricultural, and manufactured commodities, which from their low value and bulk can not be exchanged unless such cheap facilities are offered, and that there is every probability that the improvement of the Ohio River by canalization, as proposed, would induce a very large future commerce, which does not now exist, in addition to retaining and greatly facilitating and cheapening the commerce which the river now bears.

In discussing the maintenance of the 9-foot project, the board estimates it at $800,000 per annum, not including the dredging of silt, which would accumulate in slack water, or at $1,000,000 per annum if this item be included.

This project, which was reviewed and recommended without qualification by the Board of Engineers for Rivers and Harbors, in a report dated October 18, 1907, has for its object the single purpose of promoting inland navigation, and it illustrates clearly the relation which any plan for canalization of a stream bears to the general problem of water circulation. The plan deals with the water after it has reached a navigable river, when it is no longer a question of control of surface waters, but merely one of more or less effectively regulating their distribution and flow. The delay which may be imposed by storage in slack-water basins is not an appreciable factor

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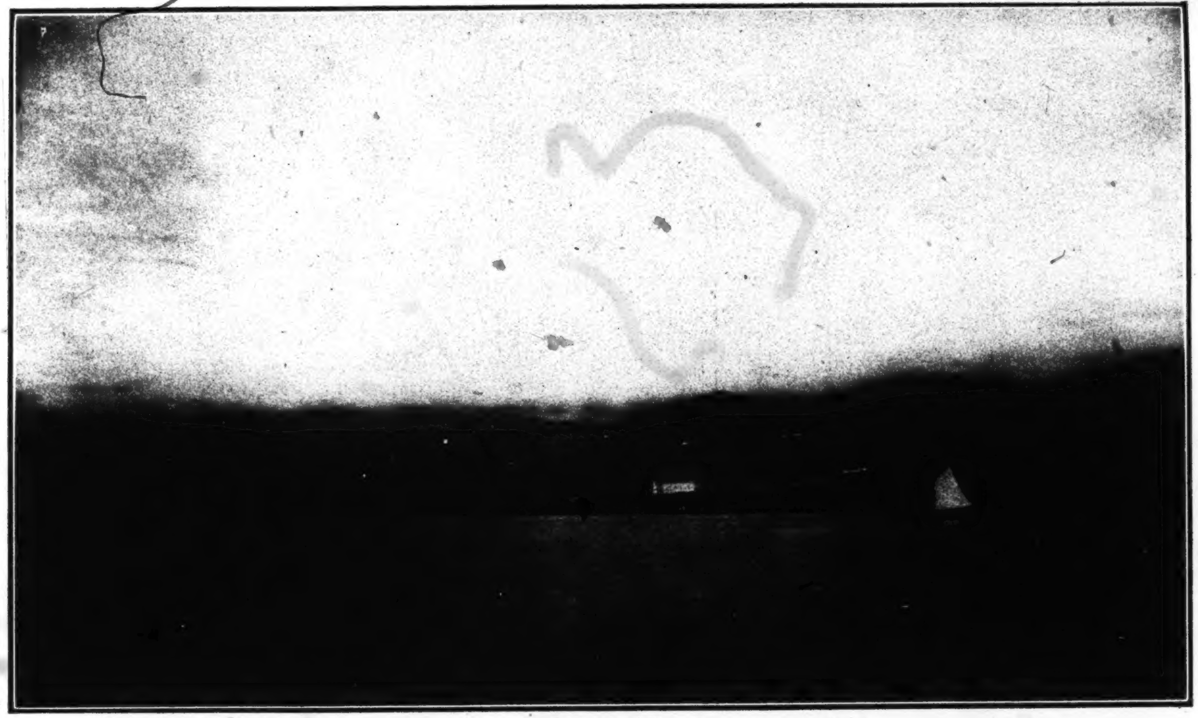
[a] 60th Cong., 1st sess., H. R. Doc. 492.



NO. 7.—DALMATIA, THE EASTERN COAST OF THE ADRIATIC.

The district from which the Romans built their navies. The dark areas consist of underbrush and small trees. (Photo by B. W.)

NO. 8.—DALMATIA. VIEW FROM THE DEFORESTED MOUNTAINS LOOKING DOWN ON THE ADRIATIC.

When forested these mountain slopes were covered with a deep soil which hid the limestone rocks that now protrude through the thin grass. (Photo by B. W.)

in reducing the damage due to floods such as those which now annually work havoc in the Ohio Valley. Moreover, the project itself establishes interests which lie within the zone liable to flood, and in proportion as it is successful and such interests grow in value, so grows the necessity for diminishing and preventing floods. Thus canalization bears the same relation to plans for conserving and controlling water circulation that any concentration of civilization bears to it. It increases the burden of responsibility for proper measures of control, whether in detail as applied to raindrops or in gross as applied to flood run-off, and the larger the wealth to be protected the greater the justification for large expenditures on account of protection; but more than this, for it is not a question of engineering and financial expense alone, the larger the national interests involved the greater the individual responsibility of every patriotic citizen to his local community and to the commonwealth in general for a proper discharge of his obligation to take care of his share of the nation's assets.

CONTROL OF GROUND STORAGE AND RUN-OFF THROUGH AGRICULTURE.

On a reasonable estimate one-half of the domain of the United States must eventually be farmed to maintain the population and prosperity of the country. The essential characteristic of the great farming area, exclusive of irrigation districts, is that it shall have soil and sufficient rainfall. Rain falling on soil is partly stored as ground water, but also partly runs off. The stored water is absolutely necessary to the farmer's prosperity, which will increase as he increases ground storage; the other is wasted, and if it causes erosion is destructive.

In considering the relation of the farmer's activities and the methods which he can employ to increase ground storage and decrease erosion we must distinguish between lands that are level or nearly so and lands that have a more or less pronounced slope.

Water control on plains.—In regions of great plains or plateaus, where lands are level or nearly so, the methods which may be used by the farmer to increase ground-water storage are the methods of good tillage which at the same time yield the largest crops. They consist in deep plowing, proper cultivation during the growing season, crop rotation, and the maintenance of an open condition of the soil during periods of fallow. The object of these methods is to increase the capacity of the soil reservoirs and to open and keep open the channels through which the rain or melting snow has access to them. Run-off and erosion are restricted in proportion as this aim is secured.

To grow large crops takes a large amount of soil moisture. The soil gets it directly from rains or in seasons of drought from the ground water which is supplied by rains that pass down through the soil to the water table. The rain that soaks in is stored for the crop. The rain that runs off is taken from what might be stored, and is not only lost but, being muddy, is also lost soil. Good tillage reduces these losses by maintaining those conditions of soil and subsoil under which a large proportion of a given rainfall will be absorbed.

In general, we say that an open soil will absorb most water. The openness of texture of a soil depends upon the sizes of the particles of which it is composed and the relative numbers of particles of these several sizes—that is, its mechanical composition. There is for any kind of soil a state at which it is in the loosest and best physical condition—that is to say, a state of arrangement of soil particles according to size and spacing in which there may be the largest amount of water gathered about the particles as capillary films and between them in delicate columns. The condition is one which is well known to farmers as that which will yield the best crops. This mechanical condition of the soil is reached by plowing, harrowing, and cultivating when the soil is neither too moist nor too dry.

The facility with which rain enters a soil depends upon its being in the above-described condition—open, yet not too open. The films of water within it are then of such size and are so distributed that they support the open texture. When rain falls it enters each little capillary tube between the grains and penetrates rapidly in the many minute channels. Thus the soil, though moist, absorbs more water than if it had been drier to begin with.

When soil is very dry and powdery rain does not penetrate far into it. There are several conditions that produce this well-known result. Much water is used in filling the large volume of the small spaces between the soil grains; the capillary films are still separate at the bottom of the sinking moisture and they sink deeper only as they join, and the air in the soil, being imprisoned by the water that fills the upper layer, offers effective resistance to percolation.

The absorbent character of a soil determines the amount which the immediate surface will take in, but it does not determine the rate at which water will soak into the lower layers of the soil and subsoil; if the latter is impermeable, the pores of the surface soil may become so filled that no more water can enter, and the rest of the rain runs off. This happens when a heavy rain falls on a field that has been plowed only 3 or 4 inches deep, leaving an unbroken clayey subsoil. If the field is level, pools of water will stand over it till they dry up. If the field be on a slope, the gathering water runs off along and across the shallow furrows and takes more or less soil with it. Where the subsoil is broken to 12 or 14 inches by deep disk plowing the same heavy rain sinks in completely and is stored for the crops when needed. The soil also stays.

Thus on plains the conditions which affect percolation of rain into the soil and subsoil and which are consequently to the advantage of ground-water storage are—

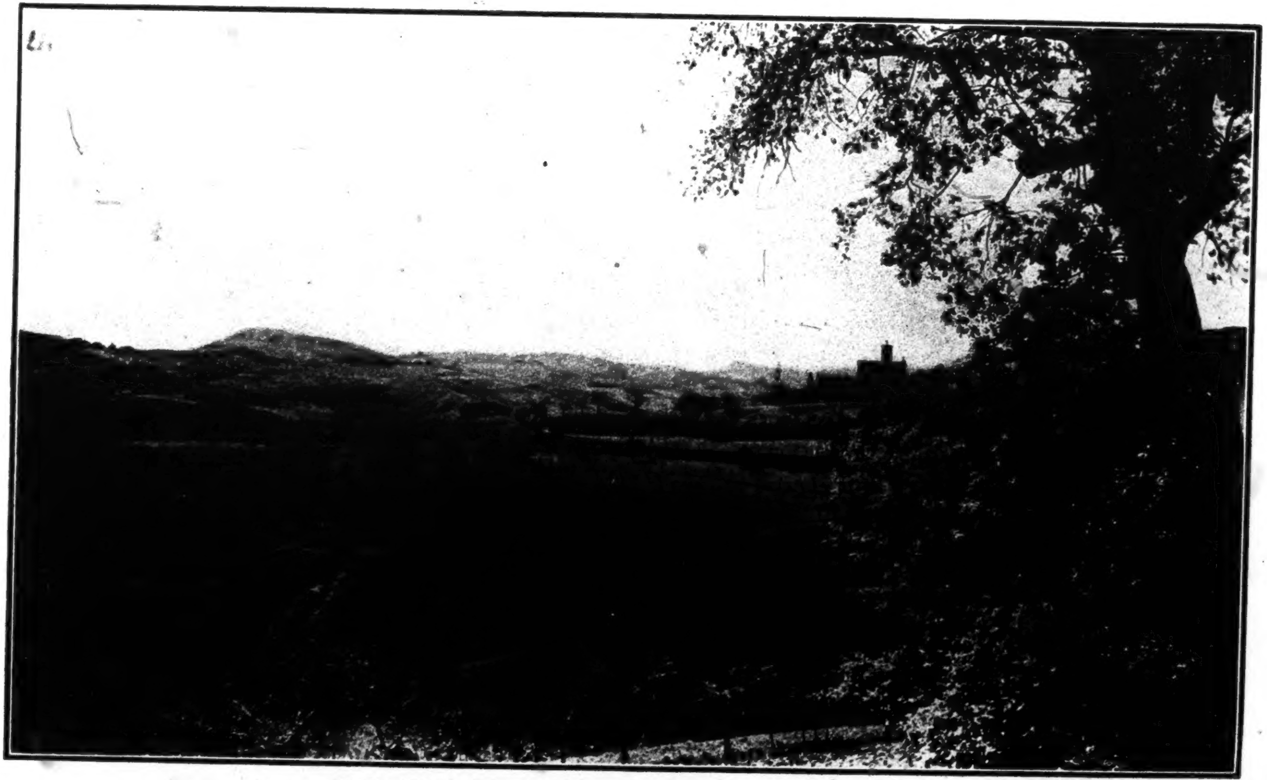
(*a*) That the cultivated surface shall be level or but gently sloping;

(*b*) That the surface soil shall be in that condition which is best described by the gardener's term of "live soil;"

(*c*) That the lower soil and subsoil should afford the largest possible amount of space into which the water from the surface may run.

Another means which is at the farmer's disposal is that of crop rotation. Clean cropping year after year exhausts the plant food and humus of the soil, affects unfavorably the mechanical condition of the soil, and brings it into a state in which its fertility is greatly reduced and it is most easily eroded. In order that these effects should be prevented it is important to introduce a rotation of crops, including grass or clover, whose deep and thickly matted roots help to open up the texture of the soil and to restore that essential constituent, humus.

NO. [illegible]—DALMATIA. EFFORTS TO REFOREST THE REGION DENUDED DURING ROMAN OCCUPATION AND LARGELY ABANDONED TO EROSION DURING THE CHRISTIAN ERA. (PHOTO BY B. W.)



NO. 10.—ITALY. NORTHERN SLOPES OF THE APENNINES, NEAR BOLOGNA.

View showing the general absence of timber with extensive cultivation of all gentler slopes. Care is taken to prevent the development of gullies, and erosion is checked so far as practicable under the conditions of use of the land for agriculture. (Photo by R. W.)

We have thus far considered only how the farmer can produce a condition of the soil and subsoil which will reduce run-off and increase ground storage. It is also important when the water is in the ground to keep it there, except as crops need it. It should not be wasted by useless plants nor by evaporation.

The waste by weeds is obvious. A growing weed takes water which the useful crop might have. The remedy—keeping out weeds—is equally obvious and is limited simply by cost.

Evaporation exhausts ground water most effectively when there is free circulation from the ground water to the surface. This happens when the films of water about the soil grains are in contact and there is ready movement in them. As the water immediately at the surface is vaporized, an additional supply is drawn to the surface through the capillary films from below. This is evaporated in turn and more is drawn up, and so through evaporation and capillary attraction the soil moisture is gradually dissipated into the air.

That condition of dryness which stops the upward movement of ground water by breaking the continuous water films is not readily established in humid regions, where the ground water lies not far below the surface and rains are not infrequent. Thus it appears that since in humid regions the farmer can not effectively restrict evaporation, he must resort throughout the entire year to every method of cultivation, and from year to year to the method of crop rotation, to keep his ground in the best possible condition for the largest storage of ground water, from which will follow also the largest return of any one crop. In the arid region nature comes to the aid of the farmer and gives him a means of stopping the loss of the precious moisture of which under the best conditions he can scarcely conserve enough.

When the farmers of America understand how to store and keep water in the ground they will have learned how to grow larger crops. Our average yield of wheat instead of being as it now is 14 bushels to the acre will then be nearer the average yield of Great Britain, 32 bushels.

Water control on slopes.—In regions where steep slopes are cultivated the methods appropriate to level fields find their application also, but they are insufficient, for the tendency of the water to run off lessens the time of its contact with the surface, and thus increases the proportion which escapes at the expense of the proportion that is stored. In a like degree erosion begins and is maintained on slopes, the soil is undercut and removed, and the subsoil or rock exposed. Forests would prevent this, but if the steep slope is cleared for cultivation it is necessary to substitute a series of steps for the smoothly inclined surface, in order to reduce these effects to a minimum.

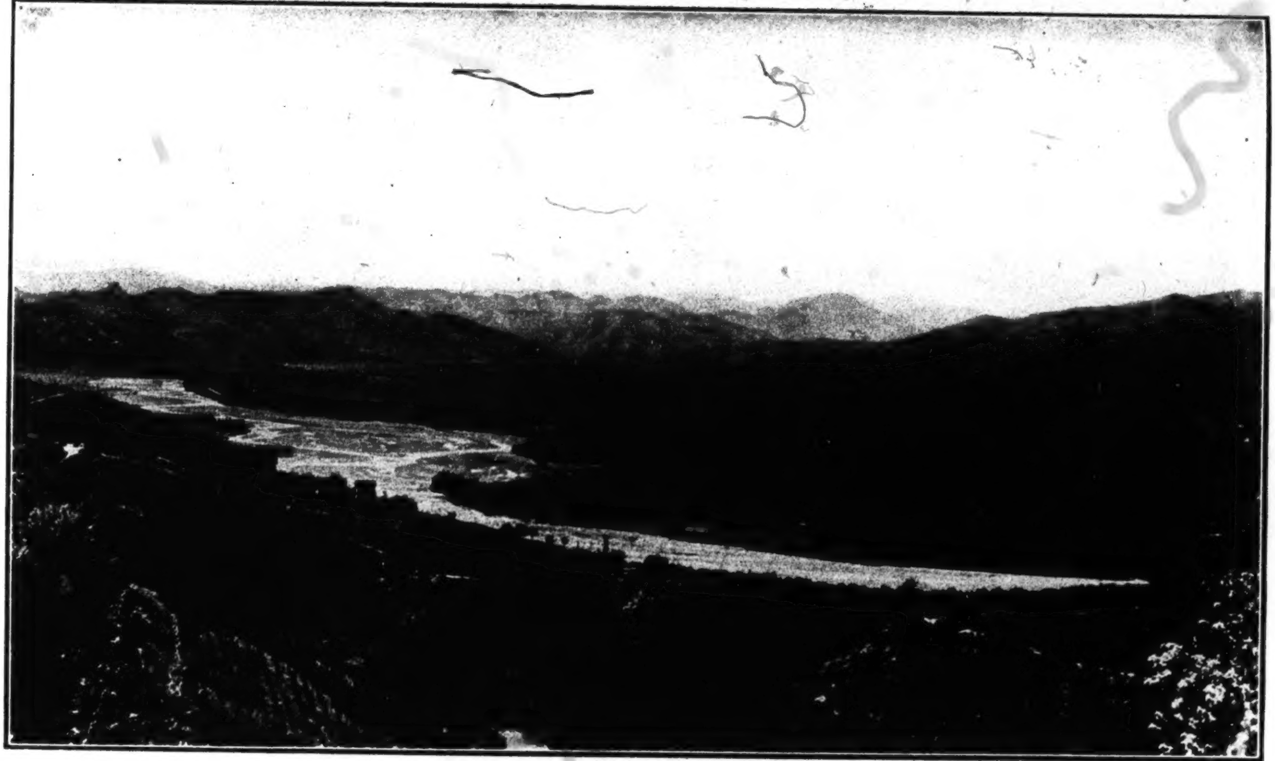
This introduces a condition which is not yet necessary in America to any great extent, but which is general throughout Europe and Asia, namely, terracing. The object is to catch rain and snow on a level. The level may be the furrows of a plow or of a harrow, provided the slope be so gentle that these suffice to hold back the water and prevent it from running and gullying the fields. On steeper slopes the harrow and the plow are inadequate, and the farmer is obliged to introduce low steps or terraces which vary in character from a little bank of sward to walls of stone. The fields above the banks of sward or above the stone wall are carefully leveled and the water which falls upon them is retained. Agriculture is thus extended not only over far-spreading plains and lowlands, but up the steep banks of river gorges and ravines. The famous vineyards of the Rhine are planted on rock wall terraces, on steep slopes such as we abandon to erosion. As our population increases and the demand for agricultural land becomes more urgent we, too, will build terraces, and high river banks throughout the humid regions will grow special products. Land hunger will eventually force us to it—not soon, however—and in the meantime our steep cleared lands can not be left a prey to erosion. They must be recovered where gullied and must be protected from gullying by watchful care, such as that which guards Holland from the sea. Our enemy is no less dangerous, not a whit less insidious and persistent. Since terracing is a possibility of the future only, we must restore the forest trees. They have held the soil during ages and in them we can confidently rely.

We are wont to think that reforestation is a need of high mountains only, but the need is not thus limited. It extends to all steep cleared slopes. Thousands of miles of these stretch along our rivers, from Georgia to Maine, from Mississippi to Minnesota. Throughout the humid region they border every river. Along all their length, in all their ramifications that penetrate the richest agricultural districts, they must necessarily be covered by trees.

From the plains and gentle slopes appropriate to farming there rise in all hill and mountain districts steeper slopes that are not appropriate to farming. When farmed they are quickly eroded and destroyed. It may be set down as an obvious economic principle that no land is appropriate to a use which destroys its usefulness. This principle is not affected by the fact that ignorant persons clear and cultivate such land extensively. In the southern Appalachian Mountains it is commonly but five years from virgin forest to abandoned fields. The mountain slopes are not agricultural lands. Themselves destroyed by erosion, they damage other lands and the water courses below them. When that damage is assessable by law upon the ignorance that causes it, agriculture will be restricted to appropriate fields.

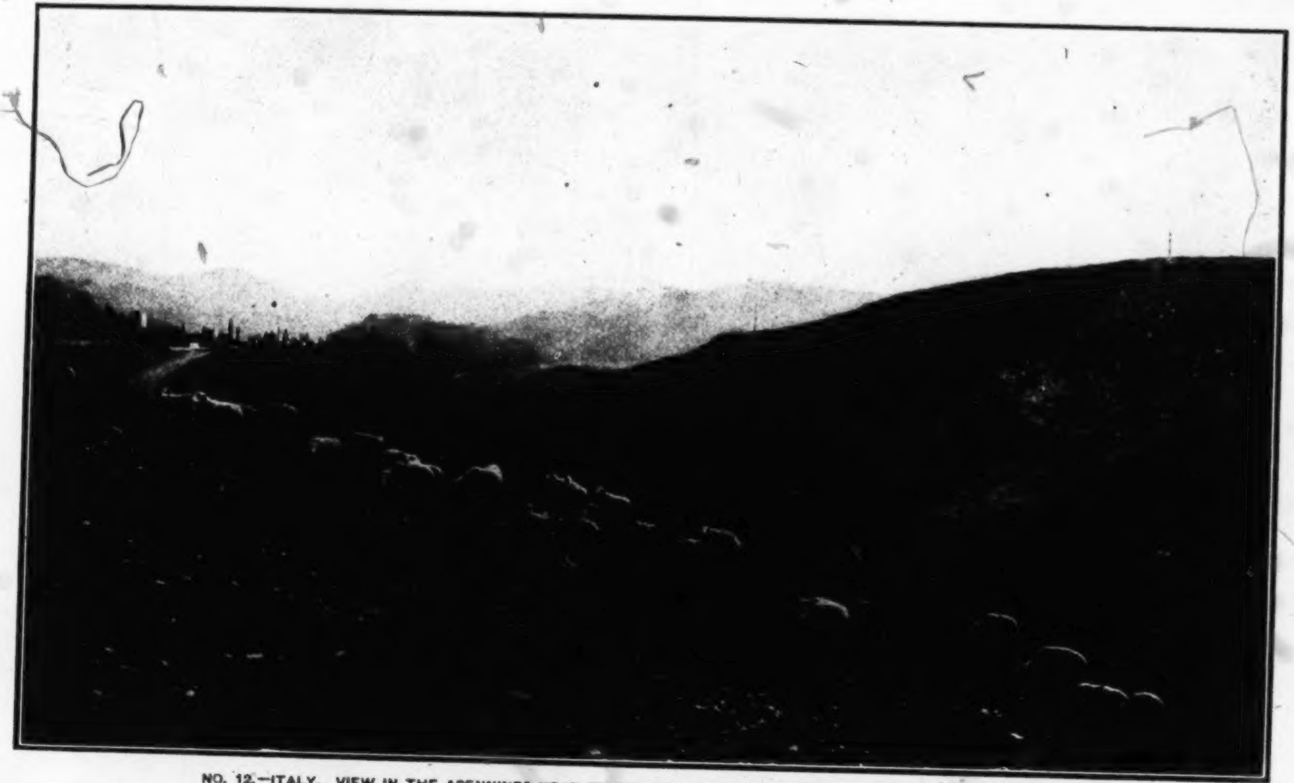
CONTROL OF RUN-OFF THROUGH GRAZING.

About 25 per cent of the area of the United States is so situated with reference to topographic and climatic conditions that it will best raise hardy grasses and must be devoted chiefly to grazing. The principal area is that of the great plains, extending from northwestern Montana around the base of the Rocky Mountains to Texas, but including also portions of the basin region on the west. Within this area the governing condition is a meager precipitation. The soils are appropriate to agriculture, the mountain ranges above the plains are suited to forestry, but both agriculture and forestry require more water than the grass that feeds herds, and they are accordingly limited in distribution in this region. The herdsman's prosperity depends absolutely upon the grass. It is proved beyond dispute that overgrazing injures the grass, partially removes the protective cover, and promotes erosion. Erosion eventually results in the removal of all herbage, produces bare, gullied badlands, and makes restocking with grass impossible.



NO. 11.—VIEW OF THE VALLEY OF THE RENO AND THE NORTHERN APENNINES, NEAR BOLOGNA,

Showing the shallow meandering river among the sand bars that are composed of wash from the deforested mountains. (Photo by B. W.)



NO. 12.—ITALY. VIEW IN THE APENNINES NEAR FLORENCE, LOOKING FROM MONTE SENARIO TOWARD FIÉSOLE.

Showing the denuded hills, the shallow, stony soil which remains after the loam has been washed away, and the sheep whose grazing removes the slight protective cover of vegetation and promotes the final process of erosion. (Photo by B. W.)

The method available to the herdsman for the limitation of run-off and the prevention of erosion is to increase the stand of the natural grass cover, upon which alone his herds depend. In some small areas he may find it necessary to adopt the usual methods of agriculture to check erosion, establish soil, and re-cover the surface with grasses, but in general that which any intelligent herdsman does to maintain the range upon which his herds live is that which he must do to prevent erosion and to limit run-off. Thus intelligent grazing promotes both individual and general welfare.

The preservation of grass upon the semiarid plains is of vital interest, probably, to the farming States, Minnesota, Iowa, and Missouri, and even more so to eastern Nebraska and Kansas. If it be true, as stated in the opening discussion of conditions of precipitation (p. 688), that radiation from the hot plains checks rainfall, it would follow, should they be eaten bare and eroded to badlands, that the semiarid climate would extend eastward. The plains themselves would become more arid, the farming districts adjoining them would be affected by prolonged droughts, and the climate would be unfavorably modified as far east as the western margin of the moist-air currents that flow north from the Gulf. Iowa is interested in the grass that grows in western Nebraska.

FOREST CONTROL OF PERCOLATION AND RUN-OFF.

The areas which must be kept forested in North America comprise 26 per cent of the whole continent. Of the United States 19 per cent requires forest protection or will grow trees more profitably than any other crop. The necessity for this amount of forests rests on two imperative economic conditions, (1) the value of forest products, and (2) the protection forests afford to other essential needs and activities of civilized communities.

It is not proposed here to discuss forest products, except to point out that their value maintains forests in areas where agriculture might be pursued if the forest products were not more valuable than the possible agricultural products. The distribution of forests, considered with reference to their products, is wholly one of cash returns. On this basis alone, however, the percentage area now left us can not economically be reduced until the increasing population begins to feel a scarcity of grain. The present price of lumber, the search for substitutes, and the coming timber famine sufficiently prove this.

Forests protect all civilized activities that depend on a regular supply of clear water or that are liable to injury from irregular and excessive flood run-off. They are not the only protecting agency. We have discussed the very great importance of engineering and good tillage in this respect. But wherever they grow forests do protect, and they do grow and protect where no other agent economically can.

This truth is challenged, for we inherit the habit of the ax and the saw, and the effects of our reckless use of these tools are not yet so conspicuous as to be clearly distinguishable in the gross result of natural and artificial activities. The challenge can not stand, however, against any fair consideration of the relations of forests and water in contrast to those of bare slopes and water.

In the opening pages of this paper we considered those phases of water circulation that are known as precipitation, ground water, evaporation, and surface flow. Forests affect each one of these, and each will be discussed in turn in the order named, so that we may clearly distinguish the several aspects of controverted points.

Forests in relation to precipitation.—Precipitation consists of rainfall, and in cold climates of snowfall, also, and these two kinds of precipitation are differently affected by forests. Concerning forests and rainfall, unqualified statements have led to exaggeration and contradiction by which the real facts are obscured. When a vast plain like the upper Mississippi Valley from St. Louis to the Great Lakes is cleared and brought under cultivation, no notable change in the amount of precipitation is likely to follow, for the air currents which sweep over it come from the Pacific and from the warm humid atmosphere of the Gulf. They are loaded with moisture and are driven north toward cooler zones. Rain falls from them inevitably, in spite of any minor effect of radiation from the fields of Illinois or Ohio. Were the wide surface stripped of green and soil and left a region of rock and sand, as central Asia was,[a] then local radiation would doubtless increase the irregularity and violence of rains, but the air rising from our fields of grain, though not as cool as that above a forest, is not so heated as to materially affect the powerful rain-bearing currents. Moreover, the general evenness of altitudes and uniformity of radiation from the green covering over a wide area tends toward regularity of conditions and gradual rather than violent changes. The ocean of green, whether of trees or grain, ameliorates the climate in like manner, though not in like degree, as does an ocean of water. Hence it is reasonable to expect that the total precipitation and the run-off, as indicated by stream gages on rivers fed from this region, will not show any decided change as a result of deforestation. This appears to be the fact, though careful observations of rainfall and run-off have been too recently begun and are made at stations too far apart to give satisfactory data for comparisons.

Deforestation of a mountain range presents a different case, since in the long run it results in extensive erosion and bare surfaces. Leaving this last statement to be discussed under Erosion, we may compare rainfall on wooded mountains with that on barren ranges on the basis of extended human experience. The mountains of southern Spain, the Pyrenees, the Basse-Alps of southeastern France, the northern Apennines, the Dalmatian and Grecian hills, have all been stripped and eroded. The change from green-covered slopes to brown bare steeps has been accompanied by a change from beneficent rains to destructive downpours. Statistics of precipitation in earlier times are not available for comparison with those of the present, but historical evidence is entirely adequate to prove that deforestation of a mountain range has modified the conditions of precipitation in such a manner that occasional heavy destructive rains replace gentle and more frequent showers, at least in the countries mentioned.

These countries differ from northern Europe in a measure as the semiarid region west of the one hundredth meridian in North

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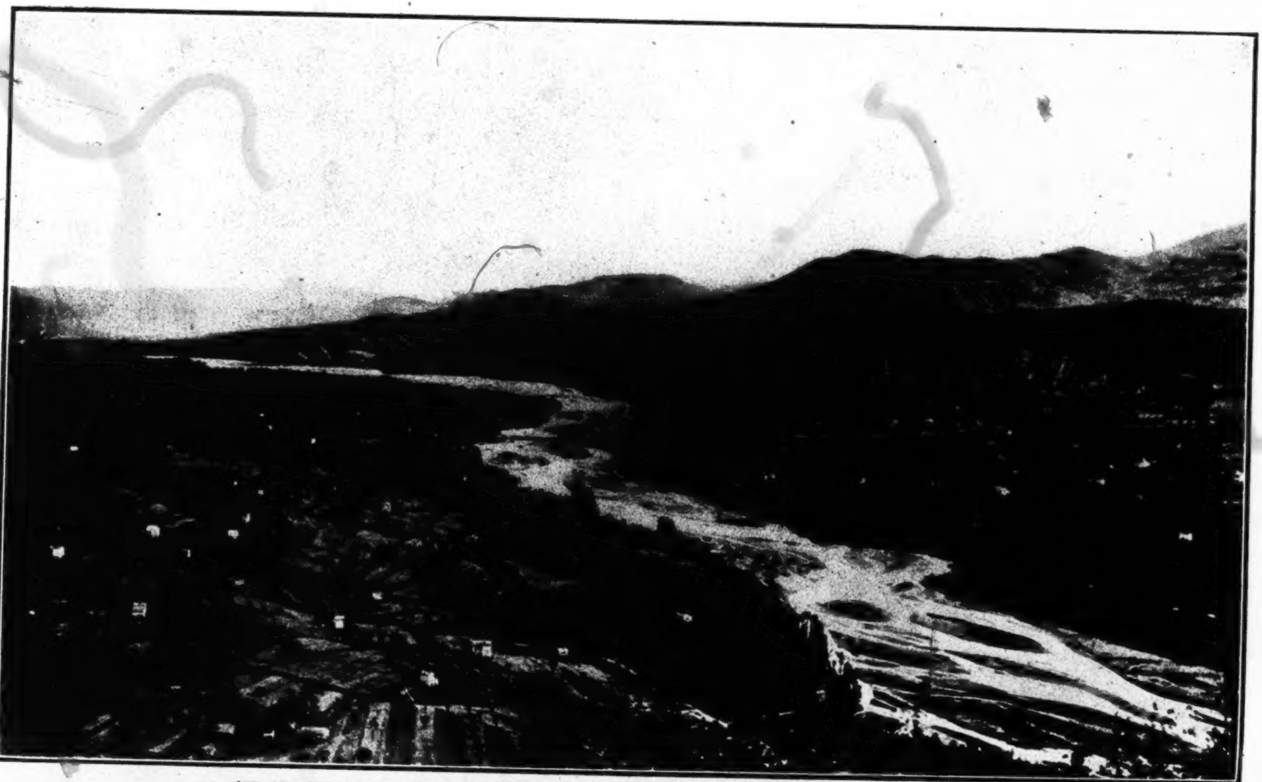
[a] Pumpelly, Raphael: Relations of Secular Rock Disintegration. Am. Jour. Sci., vol. 18, Feb., 1879.

NO. 13.—FRANCE. VIEW OF DIGNE IN THE VALLEY OF THE DURANCE. (PHOTO BY B. W.)



NO. 14.—FRANCE. SCENE IN THE BASSE-ALPES, IN THE VALLEY OF THE DURANCE NEAR DIGNE.

Showing the deforested and eroded mountain slopes and the overloaded river, which is unable to remove the sands that fill its channel. (Photo by B. W.)

America differs from the Mississippi Valley. To this fact is due in large part the difference of opinion which exists among European writers as to the influence of forests on precipitation, springs, and run-off. Those who have observed in northern Europe the effects of deforestation of flat lands under humid climates minimize or deny entirely any influence exerted by forests; while those whose experience is with warmer, more arid, and consequently more critical conditions in mountainous southern Europe are convinced that forests exert an important beneficial influence upon rainfall, ground storage, and surface waters. To cite the latest conclusions we may quote from Cipolletti.[a]

> It is generally admitted that regions covered with forests have a lower temperature than the open country, and the reason assigned for this is the evaporation from the surface of the leaves moistened by the rain, the area of which surface is estimated by Mr. Schleiden at fifty times that of the ground. Another cause is the constant evaporation during the vegetation season by exhalation of the same leaves, which Mr. Lafosse estimates at 150 cubic meters per hectare and day; and, finally, the large quantity of heat lost through the fixation of carbon, which the same Mr. Lafosse, upon the data furnished by Messrs. Lecart and Parisel, estimates, per hectare and day, at so many calories as will melt a block of ice 316 cubic meters. On the other hand, these same quantities of water which the forests continually emit into the atmosphere must help to increase the degree of humidity of the parts which immediately surround them. Thus, while on the one hand the temperature is lowered, the humidity is, on the other hand, increased; and hence it appears to be quite a logical and natural conclusion that within the forests the point of saturation of the air must be reached more quickly and more frequently than in the open, and consequently rain will also fall more frequently and in greater quantities.
>
> This theoretical conclusion is borne out by abundant facts and experimental data.
>
> Mr. Riedel quotes the island of St. Helena and Lower Egypt. On the former, owing to reforestations effected on a large scale, the rainfall has actually been doubled since the times of Napoleon I; and in Lower Egypt, where in the eighteenth century rain only fell on from ten to twelve days in the year, the number of rainy days nowadays reaches from 30 to 40, since some 20,000,000 of trees have been planted. On the other hand, on the shores of the Mediterranean, in Syria and Palestine, there are numerous regions which were formerly in a flourishing condition, but have become to-day arid and waste in consequence of the destruction of forests.
>
> Mr. Ponti refers to the observations made at the Nancy school of forestry, which were confirmed in Russia by Professor Volsky, and by which it has been found that the rainfall in the interior of the forests was greater than outside of them. He adduces also the facts that in England, although it has not been possible to prove that the deforestation has caused here any reduction in the amount of rainfall or any appreciable change in the climate generally, it has been found nevertheless that the temperature is lower in forest-covered regions, the difference being as much as 3 degrees on the hottest days.

In regions where a considerable part of the precipitation is in the form of snow the forest catches it in the branches, protects that which falls to the ground from the sun, and retards its melting. These effects bear upon the proportions that evaporate or run off or sink into the ground and will come under those heads. It does not appear that forests influence the amount or distribution of snowfall.

Forests in relation to ground water.—Inasmuch as ground water and soil moisture are wholly derived from precipitation, any effect that forests may have in regulating rain extends to them. As compared with bare ground which receives all the rain and snow that fall, the ground beneath trees gets only a part, as they catch some proportion in their foliage. The percentage caught varies from 20 to 40 per cent of the precipitation measured in adjoining fields, according to the kind of trees, the density of stand, and other factors. Thus, if the conditions for percolation are the same under the trees and in the open, the earth under the forest receives less than that under the bare surface. An approximation to this assumption is reached on level plains, provided the soil in the open be in an excellent state of tilth.

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[a] Permanent Intern. Ass. of Navigation Congresses. X Congress, Milan, 1905. Report by Cipolletti, C., on Deforestation, etc.

That proportion of the rain and snow which reaches the ground under the trees wets the mulch of mosses, leaves, and decaying wood, and such part as is not thus absorbed seeps into the ground below. Only a small part escapes as run-off, unless the slopes be very steep. The mulch of decaying vegetable matter is extremely absorbent and will hold as much as 50 per cent of its own volume, or two to three times its weight of water. From extended experiments in Germany with straw, leaves, and humus it appears that the moisture thus caught is evaporated to the air in dry seasons, and it would therefore be uneconomical from the point of view of ground-water storage to increase the surface litter beyond that required to prevent run-off. Under some conditions of forest maintenance it would probably be economical to keep the surface comparatively clean of litter and in an open state, such that the rain sifting gently through the foliage would be absorbed by the ground in a maximum degree.

The subsoil beneath the forest near the surface is moister than that beneath the adjoining fields. This is due chiefly to the covering of moist surface litter and to the relatively small evaporation at the ground surface. Deeper in the subsoil, at depths below a foot, the forest soil is often drier than that below the adjoining fields, for the tree roots take a large amount of water which is given off through the foliage. Thus, if we contrast the soil condition under the forest with that under the bare field we shall find the ground beneath the forest moister near the surface and drier below. The continuity of water films in the ground is a condition which promotes percolation, and the relatively moist surface layer thus aids the falling drops in reaching the deeper, drier layers when precipitation occurs. In the open, when the surface layer becomes measurably dried out and filled with air, a sudden rain may so occupy the pores of the immediate surface as to seal them against the escape of the underlying air, and the latter then prevents the percolation of water, and the impervious surface becomes one on which run-off is inevitable.

The total effect of trees in preventing some proportion of the rain from reaching the ground and in using some part of the moisture contained in the ground in their physiological processes is indicated by the depths to which they depress the level of ground water as compared with that in adjacent fields. Observations on this point have been made in Russia, France, and Germany, and the results are in agreement for European conditions. They were made on level ground, and the conclusions do not apply where run-off from the surface is copious. It is shown that—[a]

(*a*) The water table lies deeper below the surface under a forest than outside of it, if account be taken of the relief;

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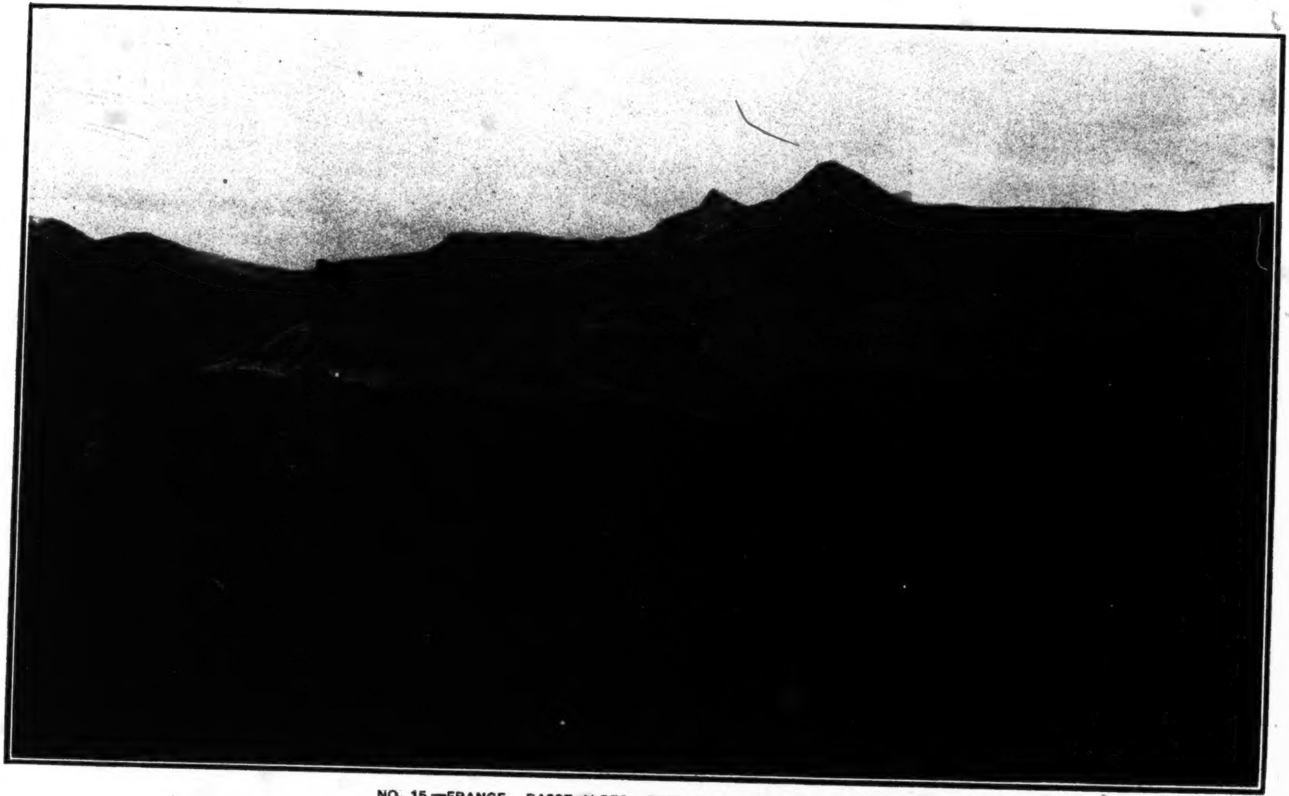
[a] Henry E.: Les Forets de Plaine, Les Eaux et Forets, vol. 42, 1903, p. 161.



NO. 15.—FRANCE. BASSE-ALPES. THE MOUNTAINS NEAR DIGNE.

Showing the widely deforested slopes of the higher mountains here and there covered with straggling brush. (Photo by R. W.)

(*b*) The depression of the water table is more pronounced under old forests than under young plantations;

(*c*) The depression is more pronounced in dry climates than where there is much rain.

The amount by which the water table may be depressed varies from a fraction of a meter to as much as 3 meters. It is observed in the level steppes of southern Russia, where the rainfall is moderate, that springs are found outside of the forests rather than in them. In citing these results, it is important to insist upon the distinction to be made between level and sloping surfaces. A comparison of the ground-water level beneath the forest with that beneath a flat field in which percolation is at a maximum gives an entirely different result from a similar comparison, in case the surface is so inclined as to permit run-off from the bare ground.

According to very careful and accurate observations made in Switzerland from 1903 to the present time and still in progress, it is found that the run-off from a wooded watershed is but 60 per cent of that from a cleared watershed, all other conditions being the same; and that the maximum high-water level of the stream from the former is 30 to 50 per cent lower than that of the stream from the latter.

The same observations establish the reciprocal fact that there is a larger and more continuous percolation of water into the ground and steadier flow of springs during drought from the wooded watershed than from the cleared watershed.[a]

Forests in relation to evaporation.—At the surface of the soil moisture passes into a state of vapor and is carried away by the air; this is evaporation. At the surface of a leaf moisture is given off by the living organism; this is transpiration. Evaporation is a physical phenomenon which increases with the dryness, temperature, and movement of the air; transpiration is a physiological phenomenon which depends upon the kind of plant and its response to the conditions to which it is exposed. Evaporation from the soil draws upon the moisture contained in the capillary spaces between the soil grains and extends down to the point where the soil is saturated—that is, to the water table in humid regions, or in arid regions to the point where the subsoil is so dry that the capillary films are no longer in contact. It continues until the available moisture in the soil is so reduced that the tension of the films about the soil grains becomes great enough to resist the tendency toward vaporization at the surface and evaporation then practically ceases, although diffusion into the air spaces of the soil continues even at some depth. Transpiration from the surface of the leaf responds in some measure to sunlight and shadow, to humidity and dryness, and to temperature. Among these humidity is the most important. The rate of transpiration is, however, subject to physiological regulation, the mechanism of which is not understood. In certain experiments conducted by the desert laboratory it was found that in plants under examination the water loss due to transpiration was checked at temperatures above 79° F., whereas the checking action disappeared at lower temperatures.[b] Thus, some plants possess a means of defense against excessive transpiration during hot weather and drought, whereas the inert soil must go on yielding moisture almost to the last atom.

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[a] Engler: Der Einfluss des Waldes auf den Stand der Gewässer. Centralblatt für das gesammte Forstwesen, Jan., 1907, pp. 35–40

[b] MacDougal, D. T.: Botanical features of North American Deserts. Carnegie Institution, Publication 99, 1908, p. 86.

There is a certain amount of evaporation from the leaf surface, but it is exceedingly slight. It differs from transpiration in that it takes place through the tissue itself, whereas transpiration occurs through the stomata. A grape which has no stomata gives a good illustration of the very small amount of evaporation from such surfaces.

Underneath the trees in the forest the conditions are much less favorable to evaporation from the soil than in a bare field near by, the humidity being higher and the temperature very much lower. Above the trees also the air is cooler and more humid than it is at the same altitude above bare ground. This last statement requires some explanation. Sunlight passing through the air raises its temperature somewhat, but a more important influence is that of the currents of air set up by contact with the surface upon which the sunlight falls. We all know the heat which rises from bare ground, and how comparatively cool is the sward. Similarly the surface of the ground is hotter than the surface of the foliage of a forest. The effect of radiation from these two contrasting surfaces is shown by the experience of French aeronauts to extend to a considerable height. According to E. Henry:[a]

> The cooling effect observed by æronauts in passing over forests of a certain extent is indicated by a marked descent of the balloon. It is a well-established fact that this effect was experienced by a number of military balloonists above the forest of Orleans, the balloon being at an altitude of about a thousand meters. It appears to be demonstrated by the balloon ascensions made up to the date of the statement that the influence of forests of similar extent (34,000 hectares, or about 20 square miles) is observable up to an altitude of 1,500 meters.

To sum up the preceding considerations: The effect of these complex relations has been made the object of investigation, particularly in Germany, through the study of the amount of moisture remaining in the soil under the various kinds of trees, and in the adjacent open. Some reference to these results has already been made; but the general conclusion is that the effects of transpiration from luxuriant foliage are very materially greater than those of evaporation from the bare level surface.

The most striking illustration of this factor is the effect of eucalyptus trees, which, planted in the Pontine marshes near Rome in 1870 (in the vicinity of the Convent of St. Paul of the Three Fountains), have lowered the level of the ground water several decimeters. In this case the transpiration from the water-loving eucalyptus is more vigorous than was the evaporation from the water and vegetation of the swamps.

The relation of the forest to run-off on level lands is not an important factor. As we have already seen, it is possible to keep level fields in such a condition of tilth that the amount of run-off from them is no greater than that from the forest. On slopes the case is different.

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[a] Henry, E.: Sur le rôle de la forêt dans la circulation de l'eau à la surface des continents. Comptes rendus du Congrès des sociétés savantes en 1901.

The effect of the forest is, first, to diminish the violence with which the rain strikes the ground and compacts it, for the drops are checked by the foliage. They fall from branch to branch and reach the ground with greatly diminished momentum and in a finer state. That portion which drops from the leaves comes in larger masses, but still gently. Beneath the forest the rain finds a moist soil whose capillary water is capable of vigorous downward circulation. The soil is also opened by the forest roots, and being protected from the compacting and cementing influences of a free exposure is decidedly porous. All these conditions militate against run-off and promote absorption. In consequence the run-off from forest areas gathers slowly as compared with bare slopes, and the ratio becomes increasingly favorable in regard to forests as slopes become steeper. This fact enters into the consideration of the value of forests in mountain regions as compared with those on plains. Ebermayer,[a] from whose paper many of the data used in this report have been taken, says:

> In view of the exact investigations which have been cited above, and which extend through thirty years, it is no longer possible to maintain the assumption so generally made, that forests increase the amount of ground water and constitute a storage reservoir for the supply of springs, *at least not so far as plains are concerned*. The draining effect of the forest is, on the contrary, so great that a much greater supply of water gathers in the depths beneath a treeless plain than beneath dense woods, provided that the underground conditions be the same in both cases. It follows that under these conditions the discharge of springs is not increased, but lessened, by woods. *Decided emphasis must, however, be laid upon the fact that these conclusions hold primarily only for the plains, and are not to be extended inconsiderately to uplands and mountains.* Although the influence of the woods upon soil, moisture, percolation, and ground water under like conditions must be the same in mountains as it is in lowlands, and only moderate differences are likely to appear, nevertheless the forest on the mountain differs very decidedly from that on the plain in regard to water control, inasmuch as in mountain regions, in consequence of the surface run-off of rain and snow water from the slopes, a factor is introduced through which wooded mountain slopes receive a much larger amount of water than bare, unwooded watersheds.

Forests in relation to erosion.—The emphasis which Ebermayer lays upon the loss through run-off from bare slopes is in no sense exaggerated. The detrimental character of this loss in relation to storage of water for all the activities of civilized communities, including navigation, can not be exaggerated. Its effects have already been described in speaking of flood run-off, but we may here recur to the injury which it does, particularly with reference to the erosion of soil. If it were conceivable that we could adjust our activities to the loss of one-half of the available water through flood run-off it would still be inconceivable that we could permit the accompanying loss of the soil. Without soil the earth becomes a desert. Without soil man must cease to exist.

This consideration is of prime importance everywhere, but it assumes overshadowing importance beyond any other in mountain regions of large rainfall. The Appalachian Mountains constitute such an area of great extent and of very marked character, and they occupy a very critical position in the center of the richest half of our country. Concerning the effect of uncontrolled run-off from this region we have, unfortunately, abundant evidence, the emphatic testimony of ruined and abandoned lands.

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[a] Ebermayer, Ernst: Einfluss der Wälder auf die Bodenfeuchtigkeit, auf das Sickerwasser, auf das Grundwasser, und auf die Ergiebigkeit der Quellen. 1900, p. 38.

Summing up the observations of the thoroughly qualified and unbiased observer, L. C. Glenn, we are able to show what relation the destruction of the forest bears to run-off in the watersheds of the southern Appalachians.

Forty-six creeks and small rivers, whose watersheds may be described as timbered rather than cleared, are known, according to observation and local repute, in times of flood to rise gradually, to continue high for several days, and to subside slowly. They carry but little sediment, and they maintain a good volume of water during dry seasons.

Thirty-eight creeks and small rivers in the same watersheds, whose slopes may be described as cleared rather than timbered, are known, according to observation and local repute, in times of flood to rise rapidly to extreme flood height, to carry excessive quantities of mud, sand, and gravel, and to fall quickly. In dry seasons they are very low, and the range from lowest to highest stages has increased and inflicted much damage in very recent years.

Two other classes of conditions may be recognized in Professor Glenn's descriptions: The one, of valleys still timbered, but which are being damaged by beginning of logging and particularly by erosion of logging chutes; the other, of watersheds that are largely cleared but grassed, and which the grass protects from erosion, though not in the same degree from rapid run-off.

Such evidence as this, collected by a qualified and impartial observer with reference to individual watersheds, establishes for the region in question, comprising the mountains of North Carolina, Tennessee, and Georgia, the fact that forests exert a beneficial influence on stream flow by storing the waters from rain, preventing their rapid rush to the streams, and paying them out gradually afterwards, thus acting as true reservoirs in equalizing the run-off.

These detailed observations sustain the general facts which every mountaineer knows: That streams which flow from a forested area rise slowly, carry little sediment, and fall slowly in times of flood, and throughout the year are relatively far more uniform in their flow, whereas streams which flow from deforested regions rise quickly, carry heavy bodies of sediment, and sink early in the season of drought to minimum low-water stages.

On the basis of superficial observation it is sometimes said that deforestation as it is now proceeding in the Appalachian Mountains does not seriously affect the streams, because the forest which the lumberman cuts is soon replaced by an aftergrowth. It is true that the full effect of deforestation follows immediately upon lumbering only in extreme cases, but wherever the forest and the superficial forest soil are removed a beginning has been made in the process of erosion which will ultimately remove all the soil. The aftergrowth that follows the severe cutting and burning under modern lumber conditions is a weakened growth. It never covers the surface as the virgin forest did; the surface is always traversed by freshly cut gullies, and the level of channel grades is sunk below it from a few inches to 10 feet or more. The advantage thus given to the eroding power of thousands of rills is not overcome by any natural process. Man alone can so direct and localize a defense as to make it effective, and he does it only at great cost. It is true that under favorable conditions the soil will maintain itself till the trees of the aftergrowth become merchantable timber, and that the processes of cutting, burning, and partial erosion might under the most favorable circumstances be continued till several crops had been cut from the surface and a half a century or more had passed, but the result would be deferred merely. That result is to be seen in the bare mountains that stretch from Spain to Asia Minor and in those of northern China.

The forests have long protected the Appalachian Mountains; they were growing throughout the eastern United States when a great plain stretched unbroken from the Atlantic to the Mississippi, and they have continued their growth, though changing in species and in distribution, while the earth's surface has been raised to the heights from which the mountains are being carved. During the whole process the forests have conserved and protected the mountain slopes from washing.

Let us pause to consider the slow changes of the ages that preceded the advent of man, the destroyer—or possibly the protector.

On a vast plain covering the area of the eastern United States and Canada there grew a luxuriant forest. The plain was almost continuous. A few broad, low hills rose from it where now are North Carolina and eastern Tennessee. In the forest grew the tulip tree and the magnolia, along with many species that are now gone, but the modern oaks were not yet developed.

Within the earth titanic forces gathered gradually till their power sufficed to raise the surface slowly and to elevate the plain. Rising in a zone that reaches from Canada to Alabama the elevated plain became a plateau from which many rivers flowed to the Atlantic and Pacific. As the slopes steepened, the waters, falling swiftly, cut their channels deeply and made canyons, which widened to valleys. Genial climates favored vegetation, which during the long, slow process of mountain growth and valley carving never was removed extensively. Woods prevailed and held the soil, always adjusting their growth to the very gradual changes of the valley slopes. If perchance a steep was bared by a sudden landslide, it was in time washed clean to the hard rock and became a cliff, or caved and extended till vegetation could take a foothold again. Thus the mountains of to-day were slowly carved from the upraised mass, and ever through the ages the forest trees grew and flourished and died, generation after generation, in the soil their roots held fast and enriched and deepened. It was their destiny to outlive the mountains, whose inert mass must yield eventually to the unceasing attacks of erosion and be worn down again to a gently sloping plain, over which the forest should stretch its living covering. But man has come, he holds the forests' destiny in his hands, and his own is intimately linked with theirs.

CONCLUSION.

The effects of rainfall in critical regions are not beyond man's control.

The methods of control are incident to agriculture, grazing, and forestry, and their application pays in larger crops, better feed, and

bigger cut per acre, as well as in national welfare both present and future.

The circulation of water in the streams, like the circulation of blood in the veins, carries the effects of negligence or care through the whole body of the commonwealth.

Every farmer, herdsman, lumberman, and landowner is morally responsible to his community for his influence on waters and their effects, and should be held to that responsibility by his conscience, by public opinion, and by law.

METHODS WHICH SHOULD BE ADOPTED BY PRIVATE OWNERS TO INSURE THE PERPETUATION OF OUR TIMBER SUPPLY.

By C. S. CHAPMAN,
United States Forest Service.

IN GENERAL; METHODS TO BE ADOPTED.

The best available statistics show that in the United States the annual cut of timber is from three to four times as great as the annual growth. This fact is conducive to conjecture as to the timber supply of the future, and as to the measures to be taken to prevent a future shortage with its inevitable depressing effects on the business and development of the whole country.

Steps looking to the perpetuation of our timber supply, so far as private owners are concerned, must be along two broad lines:

1. Aid by the Federal Government and by States to private owners by legislation and assistance, making it possible for private owners to successfully and profitably practice forestry.
2. The actual practice of forestry by corporations and individuals, which alone can increase the productiveness of forest lands and insure a future supply.

These two subjects are so closely connected that one can not be treated without, to some extent, touching on the other.

IMPORTANCE TO COUNTRY OF PRIVATE HOLDINGS.

The most liberal estimate of the wooded area of the United States, that of the Geological Survey, places it at 700,000,000 acres, while others have placed it as low as 500,000,000 acres.

Of the amount estimated by the United States Geological Survey, there were on July 1, 1908, 156,082,756 acres in national forests, and 2,582,711 acres in state holdings. This leaves the area of woodland held by private owners, or which will probably pass into their hands, 541,334,533 acres, or over three times as great an area as is held by the Government and States combined. If this area represents its proportion of the timber cut of the United States, which is a fair assumption, three-fourths of the timber supply is on private lands.

It is evident, therefore, that no matter what measures are taken by the Federal Government and by the States to properly manage their forest lands, unless the great area held by individuals is properly cared for the future timber supply is far from being assured.

Since the annual timber cut of the United States is from three to four times as great as the annual growth, the situation will not be satisfactory unless, under forest management, timber can be made to grow from three to four times as rapidly as at present. A similar situation has been successfully met in other countries and undoubtedly can be in the United States.

There are at the present time, both in the hands of private individuals and of the Government and States, large tracts of land which should and will be planted. Lack of authoritative data makes it impossible to say how much land there is in the United States which does not now but would support forest growth and yield better returns from a forest crop than from any other. Combining the treeless areas of the West, the cut and burned-over lands of both East and West which are not restocking, and the land put to some kind of agricultural use but best adapted to the growth of timber, the area is emphatically worthy of consideration in connection with a national timber supply. It is, of course, true that much land now in forests could serve its highest usefulness as farm land and that, with the increase of population and with better and more intensive methods of farming, land not now considered of any value for agriculture will be used for this purpose.

It is certain, however, that this enlargement of agricultural areas to include land now forested can not permanently exceed the amount of treeless areas that should be planted, so that eventually the forest-covered area of the United States should be at least no smaller than at present. Even this means intensive forest management if the United States is to furnish its own timber supply. Economy in use and the extension of preservative treatment of timber will also serve to aid in the perpetuation of the country's supply of wood.

AID TO OWNERS OF PRIVATE TIMBER LANDS.

Many private timber holders are now practicing forest management of some nature. Exactly how many, it is impossible to say. (See Tables I and II.) A mention of the work done by the Forest Service to assist private holders will give a general idea of the interest taken. Up to June 30, 1908, at the request of owners of woodland, 568 examinations of tracts were made by trained foresters of the Forest Service. The number of cases where assistance was asked and could not be given was large. The area affected by the examinations was 10,280,783 acres, in 41 States and Territories.

In a number of cases detailed working plans were made for the conservative management of the timber tracts. Much of the cost of the work was at first borne by the Forest Service, for the purpose of stimulating interest in forest management and to secure necessary data for the Government on the growth of trees, their silvicultural characteristics, and best means of management. At present, however, the owners of woodland must bear the greater part of the expense themselves, except in rare instances where the preparation of a plan would be of unusual educational value, or when a plan has never been made by the Service in the region.

In April, 1907, the Forest Service sent out a circular letter to 100 owners of small timber tracts and to 402 owners of wood lots, requesting them to make a statement of the work done on their lands as a result of recommendations of the foresters who examined their tracts. To these letters 152 replies were received, showing that 102 were carrying out the recommendations of the Service. Twenty-one reported some work in progress and 29 had done nothing. If this may be taken as a fair sample, more than 450 of those who have received aid from the Federal Government are now practicing forestry, at least to a limited extent.

Up to June 30, 1908, 452 persons received actual help on the ground in forest planting affecting nearly 64,000 acres. In addition a large number of people received aid through correspondence. About 32 per cent of the plans made were carried out either wholly or in part.

In addition to the aid given by the Forest Service a number of States have given, through their state foresters, valuable assistance at small cost. Notable among the States well equipped to do this work are Connecticut, Massachusetts, and California.

Also, the publications of both federal and state governments have aided private owners very greatly by giving valuable information on the handling of natural forests and on forest planting.

Laws have been passed in nearly all States to prevent forest fires and other sources of forest destruction. Twenty-six States have boards or commissions whose whole or partial duty is to look after forest matters of the State, and nine of these States have state foresters. Twelve States have tax-exemption laws in some form, and several others offer rebates and bounties. There are still some States which have shown little interest and have not considered forest preservation a question of sufficient importance to warrant the enactment of laws to help their citizens.

PRIVATE FORESTERS.

As yet there are not many foresters in private employ. A few lumber companies are now employing them, and a few firms of consulting foresters are at work. The best figures attainable, however, do not show over 70 private foresters actually doing professional work or teaching.

While the interests of both Government and State make it desirable that necessary aid be given those who apply, advice on the ground and plans for caring for timber land should more and more be done by the private forester. As large companies become really interested in forest work and take it up as a business proposition, they will secure the services of trained men. As soon as the practice of forestry becomes accepted as good business policy there should be an end to the great duties of State and Federal Governments as disseminators of knowledge and stimulators of forest preservation through aid other than by legislation, and then the field can be left very largely to private foresters.

THE PRACTICE OF FORESTRY BY OWNERS OF TIMBER LANDS.

Owners of timber land may be broadly classed as—

(*a*) Those who purchase for speculation and hold for a rise in stumpage prices;

(*b*) Those who hold for game or pleasure preserve and not for profit;

(*c*) Those who either hold to supply their mill, to furnish logs for market, or to furnish fuel, posts, and other necessary timber either for home use or for sale.

Those of the first class obviously do not cut their timber, and aside from necessary protection from trespass and fire which might result in financial loss they are not interested in any form of forest management.

Those of the second class will and generally do practice forestry if it will foster any of the purposes for which the forest is held; and as forest management may mean money return without lessening the beauty or value of the forest, the owners are generally favorable to forest management. A forest of this class is that owned by the Blue Mountain and Forest Park Association in Sullivan County, N. H. This tract, which contains about 15,090 acres of woodland, is held by the owners as a permanent game preserve. Under forest management it is possible to so care for the tract that its usefulness as a game refuge is not interfered with, and at the same time a considerable revenue from the sale of timber is secured. The tract has been managed by a forester since 1904.

The third class of owners hold their land for profit, direct or indirect. This is by far the largest class and the one on which the future timber supply of the country must rest. Forest management, unless it shows good financial returns—better returns, in the long run, than under present methods—has no attraction for this class of owner. This is only natural. Many of the large holdings are owned and worked by stock companies, to secure profit on their investments. If forest management can not show a profit to this class of owners it will not be practiced. If it can show profit and this class of owners can be led to see its advantage, they will adopt it. It is therefore very important that every possible measure be taken by the Government, by the States, and by private owners to determine the proper management of timber lands in different sections and ascertain the profits and benefits to be derived.

One great drawback to forest management by private owners has been the ordinary attitude toward a timber tract. It has been formerly and is still often looked upon as a source of supply which when cut over is gone for all time; and the possibility of continuous crops is not thought of. In the case of a manufacturing plant the attitude is quite different. The company putting up a large and expensive saw or paper mill that costs from fifty thousand to several million dollars plans to have this plant run for a sufficient number of years to warrant the investment. If a supply of timber to last through this period is not already owned, the possibility of purchasing material is carefully calculated, rather than the possibility of growing a second crop. In the past it has been profitable to cut over a tract without regard to future crops, and then with the profits to purchase another tract to be treated in the same way. This practice has had extremely disastrous results, for it has left cut-over areas in a condition which it will take years to correct, and made it possible to so increase the output of lumber when prices are good that overproduction and a resultant market depression ensues.

One great argument against forest management is that because of fluctuating prices safe calculations of values can not be made a long time in advance. In older countries prices of forest products are more stable and the crops can be harvested each year in accordance with an annual or periodic production of wood. With varying prices there is a decided tendency to over-cut whenever prices are high and hold when they are low. This, of course, interferes with systematic forest management. However, stumpage is becoming more valuable, timber land more and more is getting into the hands of large companies who will hold for a second crop, and as it becomes more difficult to buy another tract from the profits of the one cut over, cutting with a view to a second, a third, and succeeding crops on the same land must result.

HOW SHALL PRIVATE TIMBER TRACTS BE MANAGED?

It is extremely difficult to say how private timber tracts should be managed. In a country that varies so greatly in climate, topography, variety of species, and market facilities, what is good management for one tract becomes bad for another; and the problems become so local in application that it is conceded by foresters that each tract must have its management prescribed after a careful examination on the ground. The application of general rules for the management of tracts in various parts of the country is impossible, and it is equally impossible to give information in a single report. Moreover, any information given would be of necessity too general to be of much real value. The Forest Service has issued publications on the management of woodlands in various sections, and some of these are given as references to any timber-land owner within a region specifically covered. Modifications will, of course, have to be made to suit individual conditions. Many other works on forestry have been published, and anyone desiring information on forest management can easily secure such information from some of the publications of the Forest Service.

List of some of the publications of the Forest Service containing valuable information regarding forest management.

GENERAL.

Bulletins.—No. 5. What is Forestry? No. 11. Some Foreign Trees for the Southern States. No. 15. Forest Growth and Sheep Grazing in the Cascade Mountains of Oregon. No. 16. Forestry Conditions and Interests of Wisconsin. No. 24. A Primer of Forestry (Parts 1 and 2). No. 42. The Wood Lot. No. 47. The Forest Resources of Texas. No. 49. The Timber of the Edwards Plateau, Texas. No. 55. Forest conditions of Northern New Hampshire. No. 66. Forest Belts of Western Kansas and Nebraska.

Circulars.—No. 10, No. 11, No. 13, No. 14, No. 21, No. 35, No. 79, No. 97, No. 140, No. 149.

TREE STUDIES.

Bulletins.—No. 12. The Timber Pines of the Southern United States. No. 22. The White Pine. No. 33. The Western Hemlock. No. 38. The Redwood. No. 53. Chestnut in Southern Maryland. No. 58. The Red Gum. No. 63. The Natural Replacement of White Pine in Old Fields in New England. No. 64. Loblolly Pine in Eastern Texas, with Special Reference to the Production of Cross Ties. No. 69. Sugar Pine and Western Yellow Pine, California.

Circulars—No. 40, No. 118.

WORKING PLANS.

Bulletins.—No. 26. Practical Forestry in the Adirondacks. No. 30. A Working Plan for Forest Lands near Pine Bluff, Ark. No. 39. Conservative Lumbering at Sewanee, Tenn. No. 43. A Working Plan for Forest Lands in Hampton and Beaufort Counties, S. C. No. 56. A Working Plan for Forest Lands in Berkeley County, S. C. No. 60. Report on an Examination of a Forest Tract in Western North Carolina. No. 68. A Working Plan for Forest Lands in Central Alabama.

Circular.—No. 131.

PLANTING.

No. 18. Experimental Tree Planting in the Plains. No. 27. Practical Tree Planting in Operation. No. 29. The Forest Nursery. No. 37. The Hardy Catalpa. No. 45. Tree Planting of White Pine in New England. No. 52. Forest Planting in Western Kansas. No. 65. Advance of Forest Planters in Oklahoma and Adjacent Regions.

Circulars.—No. 6, No. 54, No. 22, No. 55, No. 109, No. 37, No. 61, No. 45, No. 99, No. 145, No. 41, No. 100.

There are certain fundamental rules which must, of course, be followed in the practice of forestry everywhere. Timber must not be cut faster than it is produced, if an equal annual or periodic yield is desired. If reproduction is to be secured through natural means, young growth must be cared for. A tract must be at all times guarded against destruction by fire and insects. Waste in logging must be avoided. Unless restocking is to be by planting, the basis for a second crop must be left on the ground either as seed trees or young growth. Often the mere prevention of fire will in itself result in a good growth of young timber.

A number of large timber-land owners are now practicing forestry. Some of these are C. F. Craig Timber Company, West Virginia; Delaware and Hudson Lumber Company, New York; Cleveland Cliffs Iron Company, Michigan; and Pennsylvania Railroad Company.

All of these companies employ foresters. In addition there are others who, though they do not employ foresters, are doing something to protect their land and grow a second crop. The Santa Clara Lumber Company, of New York, while not engaged in systematic forest management, is leaving a considerable amount of timber standing, and is planting skid roads and other open places as soon as an area is logged over.

In the August number of the Southern Industrial and Lumber Review there is a very interesting article on the practice of forestry by lumbermen in the pine belt of Texas. The company that publishes this journal sent out a number of letters to prominent timber holders and lumber manufacturers in Texas and asked if they had any plans for conserving their timber or reforesting their cut-over land; if any attempts toward these ends had been made, and, if so, with what success. The Journal states:

> In the first place, practically all of the lumbermen declared themselves unconditionally in favor of any fair plan that could work for the insuring of future forests could such a plan be discovered. None of them advanced a feasible plan for securing such an end, and it is safe to say that no human being in all this public discussion of the matter has yet advanced a practical plan whereby the objects desired could be attained.

Three of the firms written to were taking measures to conserve their timber, and others wrote that they intended to do so in the near future.

The Southern Industrial and Lumber Review draws the conclusion from the answers received that one of the cogent reasons why forestry can not be practiced is that taxes are excessive. Its publishers also believe that if timber lands were exempted from taxation until the crop is merchantable it would be a great stimulus to the practice of forestry.

It is interesting to note that the trade journal quoted considers that no feasible plan for the management of forest lands in the Texas pine belt has been set forth. More than most regions this section has been studied by foresters, and their conclusions and plans for managing various tracts are of record. The trouble is that while many timber-land owners are now holding their land for future crops (see Tables I and II) few are doing more than this. An expenditure whose returns will show only after a long period is not considered seriously, and any plan for forest management entails a certain amount of expense. Timber-land owners, for the most part, demand a system of management which brings good results without extra expense to the business or any inconvenience in logging. Such a system is possible only in very rare instances.

Table I shows the results of inquiries to 3,629 lumber and coal companies for information about fire protection and the policy toward cut-over holdings. To these inquiries 1,331 replies were received, and of this number only 639 contained information complete enough to be tabulated.

This tabulation, which covers 24 Eastern States, shows that of a total area of 3,512,846 acres, 1,764,609, or practically half, is held for future crops, and if not now receiving some protection and care for the future, presumably will, eventually. It shows, too, that not all of the land held for a second crop is protected from fire.

It is also of interest to note that, while not quite 50 per cent of the land is held for a second crop, exactly half of the owners are holding their land for this purpose.

TABLE I.—*Forest ownership and protection.*

State.	Number firms reporting.	Amount represented.	Timber.	Held for future crop.	Protected from fire.	Number firms reporting acreage only.	Number firms holding for future crop.	Number firms protecting land
		Acres.	*Feet.*	*Acres.*	*Acres.*			
Alabama	23	309,104	567,314,000	256,466	17,830	11	11	3
Connecticut	1	950	2,250,000	950	....	....	1	....
Florida	1	13,645	40,000,000	13,645	....	....	1	....
Georgia	4	32,462	100,500,000	11,462	3,000	2	2	1
Illinois	21	5,509	7,658,000	2,302	....	16	3	1
Indiana	14	3,367	5,000,000	....	....	9	....	....
Kentucky	50	210,768	526,687,000	78,102	14,250	21	22	7
Maine	40	350,772	910,385,000	339,888	218,696	5	32	10
Maryland	14	26,753	33,840,000	3,061	....	....	7	....
Massachusetts	4	1,430	5,300,000	1,100	....	....	2	....
Michigan	1	1,280	100,000	....	....	....	....	....
Minnesota	1	1,600	400,000	....	....	....	....	....
Mississippi	1	480	600,000	....	....	....	....	....
New Hampshire	46	122,051	197,347,000	44,243	....	2	28	....
New Jersey	1	86,700	....	86,700	....	1	1	....
New York	17	35,617	131,095,000	27,382	7,250	2	12	2
North Carolina	29	515,517	1,406,575,000	242,265	482,400	4	17	5
Ohio	41	40,339	14,105,000	36,971	25,035	27	16	6
Pennsylvania	126	201,777	221,847,000	114,478	80,868	59	64	30
South Carolina	3	5,450	53,300,000	5,050	....	....	....	....
Tennessee	44	588,150	1,403,200,000	219,789	272,528	12	23	5
Vermont	33	63,425	351,850,000	44,964	7,031	2	19	4
Virginia	27	180,565	566,971,000	113,045	2,800	11	8	2
West Virginia	97	785,135	1,790,261,000	122,746	65,454	36	50	13
Total	639	3,582,846	8,336,585,000	1,764,609	1,197,142	220	319	89

Table II.—*Tabulated results, by States, of answers to 596 circulars of inquiries received from owners of timber tracts in the United States.*

State.	Number firms reporting.	Amount represented.	Protected from fire.	Number firms stating some form of forest management considered practicable.	Cut-over land held for future crop.
		Acres.	*Acres.*		*Acres.*
Alabama	7	277,000	227,000		112,500
Arkansas	21	871,185		5	70,000
California	13	216,099	156,000	1	117,000
Connecticut	16	27,250	16,500	6	22,400
Florida	13	787,400		5	25,000
Georgia	11	158,702	115,902	7	4,800
Idaho	10	81,500	69,980	2	
Indiana	3	23,218	23,218	2	173
Kentucky	11	92,460		4	72,810
Louisiana	35	1,349,136	488,000	12	440,000
Maine	12	126,300	90,000	6	126,300
Maryland	5	2,900			200
Massachusetts	37	2,036,865	10,115	17	18,590
Michigan	19	476,273	54,080	5	127,000
Minnesota	8	161,940	60,640		2,140
Mississippi	22	659,100	47,000	1	31,000
Missouri	9	264,197		1	612
Montana	14	68,620	36,460	3	
New Hampshire	9	163,200	102,200	3	142,200
New Jersey	3	3,308	3,000	1	308
New York	36	356,744	158,140	15	215,362
North Carolina	18	619,418	387,000	7	455,000
Ohio	1				
Oklahoma	2	40,000		1	
Oregon	46	357,380	309,870		174,820
Pennsylvania	12	523,467	465,167	3	112,300
Rhode Island	3	4,030			2,050
South Carolina	12	183,064	2,000	1	15,000
Tennessee	11	175,740	91,500	2	
Texas	20	835,100	191,000	1	282,000
Vermont	9	66,300	37,300	2	66,300
Virginia	12	98,000	31,000	2	50,000
Washington	71	492,413	390,650	1	261,580
West Virginia	21	427,783	273,183	2	71,000
Wisconsin	44	1,124,912	239,682	3	109,700
Total	596	13,151,104	3,976,587	121	3,128,085

Table II shows the results from 2,089 schedules of inquiry send to members of lumber associations. Many of these had sold their land or were not actually operating ~~in the~~ woods, so only 596 satisfactory replies were received. This table, unlike the first, is compiled from replies from both Eastern and Western States. In all, 35 States are represented, and the interest shown in all sections was particularly good. Of more than 13,000,000 acres represented, nearly one-fourth was being held for a second crop, and a slightly greater amount was being protected from fire.

One of the questions asked in the schedule was:

> What method of conservative forest management do you consider practicable in your section from a business standpoint?

A number of interesting replies were received.

The Rietbrick Land and Lumber Company, of Wisconsin:

> As stated, no timber 10 inches and under in diameter is cut. By taking out older trees it gives a chance to younger trees for better growth. We expect to harvest these logs in, say, possibly fifteen to twenty years. We are giving consideration to young and thrifty timber on cut-over lands with a view of future crops. We have done this for several years, before which time it was not considered.

The Eel River Valley Lumber Company, of San Francisco, Cal.:

Replanting redwood lands has been initiated to a small extent. Eucalyptus is being put out to a very limited amount. We planted last spring about 500 trees of the blue variety as an experiment. These trees were planted when about 1½ to 3 feet high on old logged-off land on a steep hill, where they were exposed to all the heat of summer and to the rain and storms of winter. No special attention has been paid to them, as it is desired to see what they will do on such land without special care. There is no water in the surface where they were set out. They have shown a strong, vigorous growth during the summer, and about 75 per cent have lived.

The Desert Lumber and Coal Company, of Arkansas:

Trees should be cut up to 12 or 14 inches diameter, younger trees left standing, and tops of trees cut should be burned up carefully; this would perpetuate our forest indefinitely.

The Conway Lumber Company, of Horry County, S. C.:

Cut no timber under 12 inches in diameter, 18 inches from the ground. Protect the small trees in cutting the big ones, and keep fire out of the forests.

The C. R. Cummings Export Company, Liberty and Harris counties, Tex.:

We cut only the larger timber and leave all small timber standing, cutting principally 12 inches and up in diameter.

The Shaw Land and Timber Company, of Tidewater, Va.:

None necessary except keeping out fire; do not cut the small timber; nature does it all in this flat country.

William Brown & Sons, of Worcester County, Mass.:

We cut off timber clean excepting a few seed pine, sowing to pine seed and reseeding from old pine trees.

Mr. Joseph H. Elliott, of Windham County, Conn.:

My method is to cut out everything ready for market and leave every small tree. The trees that are left grow faster, and in a few years another crop is ready for market.

Throughout the answers to the schedule, complaint is made of the high tax on forest crops, and legislation is suggested to lessen the burden of the owners in this respect. A number of the answers also suggest stringent government rules, accompanied by inspection, that will require private owners to leave a certain amount of timber on the ground when logging and require them to protect from fire. Several advanced the idea that the Government should buy cut-over land and hold it for a second crop, as the expense to the individual was too great.

In a large number of cases companies appear to be holding land for a second crop and, in addition, are endeavoring to keep out fire and to leave some timber on the ground. This is, of course, a very crude method of management, but in many instances it will no doubt result in the owner securing a good second crop and is an excellent indication that more intensive management will follow.

IS FOREST MANAGEMENT BY PRIVATE OWNERS PROFITABLE?

Whether or not forest management is financially successful depends almost entirely upon local conditions. It often happens that the value of a forest is indirect, but ordinarily, with fair market facilities, any tract can be so managed as to produce revenue. There is no question but that forest management pays on the farm wood lot, which is managed to supply the farm with fuel, posts, etc., and from which the farmers can cut a few ties or telephone poles for the market during a time when the farm work is dull, and thus derive a small revenue as well as have a means of employment.

With the owner who keeps his woodland as a game preserve, or as a playground for guests stopping at his hotel, or as protection to a watershed, and who would under no circumstances allow ordinary logging to be carried on within his holdings, a system of forest management adapted to the needs of the case is the only feasible plan. Any revenue derived is of course just that much gain, for, otherwise, no cutting would be allowed.

To the mill man or logger who is getting out his product to compete with others in the same business, any management which adds to the expense is questionable. It is evident that in most cases forest management adds to the cost of logging. It means marking the timber to be cut out or that to be left as the case may require; it means a lighter cut on the same area than would be the case under ordinary logging practice; it means greater care in felling to avoid injury to growth left for a second crop; it means care that fire shall not start; and it also means as complete a utilization of the tree as possible. In return it makes of a sawmill or paper mill plant a permanent investment, provided the owner has enough timber land to produce yearly an amount of timber equal to the annual consumption of the mill. It enables the owner to carry on his business without fear that high stumpage prices will force him out, for in raising his own timber he makes the cost considerably more constant. He has at all times on his land a valuable crop on which he can realize, instead of a cut-over area valuable only for pasture, or, in some cases, for which a small price may be secured for agricultural use. The small value placed on cut-over land is best shown from the fact that forest lands carried on the delinquent list in Michigan comprise 6,000,000 acres, and in California over 500,000 acres. In Wisconsin very large forest areas have been forfeited for nonpayment of taxes, but in 1907 the legislature authorized the purchase of such land for State forests. These forest lands are not worthless; they will in time yield timber again. They were allowed to revert to the State because their owners considered that being unprotected and subject to high tax they could not be held at a profit. Whether or not it would pay to plant these lands under present conditions is questionable, but if properly cut, so as to secure reproduction by natural means, they would probably have shown returns, even at an expense for fire protection and high taxes.

The profit to be derived from lands managed under forest principles has been carefully worked out in a number of specific cases by the Forest Service. Yet returns depend so largely upon the increase in stumpage price that figures of future returns are only conjectures.

The care of wild woods in the East will in nearly every case, by the use of very conservative figures, show a 5 per cent investment on the value of land and the cost of maintenance. If the value of stumpage at the end of the rotation exceeds the estimated value, greater returns will, of course, result. The following figures are quoted from Forest Service Bulletin 64, United States Department of Agriculture, Loblolly Pine in Eastern Texas:

> In the following computation estimate must enter to a considerable extent, but from the tendency of lumber prices to advance it is apparently safe to assume that, after forty years, tie stumpage will be worth 8 cents and lumber $2 per thousand. The yield of the forest may easily be more than the first crop, because it will be cared for and because the area of prairie is steadily lessening, but it will be safest to count on the same yield after forty years as is obtained now.
>
> *Estimate of outlay and returns per acre in holding cut-over loblolly pine land for a second crop.*
>
> OUTLAY.
>
> | | | |
> |---|---|---|
> | Cost of land | | $0.50 |
> | Interest on same at 5 per cent | $0.025 | |
> | Taxes, at 1 per cent of value | .005 | |
> | Cost of management | .050 | |
> | Annual charge | .08 | |
> | This 8 cents paid annually for forty years, and with compound interest at 5 per cent amounts to | | 9.66 |
> | Total | | 10.16 |
>
> RETURNS AT END OF FORTY YEARS.
>
> | | |
> |---|---|
> | 80 ties, at 8 cents each | $6.40 |
> | 2,500 board feet of lumber, at $2 per M | 5.00 |
> | Land will sell for | 1.00 |
> | Total | 12.40 |
> | Less outlay | 10.16 |
> | Net profit | 2.24 |
>
> This shows a 5 per cent investment with a margin of $2.24, or a net return of a little less than 6 per cent on the outlay. There is little doubt that this rate can be considerably increased in many cases, because all the figures used are conservative. If ties are cut more carefully, for instance, it will be possible to get at least 10 more from each acre, which means 80 cents, and increases the return on the investment to 6 per cent.
>
> Other elements of this question are too problematical to be set forth in figures with safety, yet they deserve to be considered. First, the forests of eastern Texas are nowhere as dense as they might be, and it will require only a little care to increase the average stand from about 140 trees to the acre to at least twice that number. In addition, the actual forest-bearing area can be increased by reclaiming the marshes which now form so large a part of the region that the actual forest yield in these calculations is one-third of what it might be. Second, the tie supply must be kept up, and a plan which promises to do it while paying upward of 5 per cent compound interest is worthy to form part of the maintenance system of the railroads which are interested in that section.

But the best proof that forest management pays is secured from timber prices abroad, where every country but Turkey and China manage their timber lands in accordance with forest principles. In Prussia in 1904, the net return from forests was $2.50 per acre; and this is nearly ten times what it was sixty years previous.

In Saxony the net yearly revenue from forests is $5.30 per acre, the yearly expense $3 per acre. The following table is taken from Forest Service Circular 140, What Forestry Has Done. It shows what has been done by governments, states, and communities; and there is no reason why tracts held by private owners should not do equally as well as government holdings.

What forestry has done in other countries shows, first of all, that forestry pays, and that it pays best where the most money is expended in applying it. Both these points are very clearly brought out in the following table:

Expenditures and revenues of national forests, showing increased productiveness under larger expenditures.

Country.	Total net revenue from government forests.	Expenditure per acre.	Net revenue per acre.
Wurttemberg	$3,098,428	$2.05	$6.60
Saxony	2,299,000	3.00	5.30
Baden	829,102	3.58	4.42
Hesse	744,209	1.25	4.29
Switzerland	237,663	1.32	2.55
Prussia	17,054,144	1.58	2.50
Bavaria	5,128,348	1.99	2.22
France	4,737,250	.95	1.75
Italy	....	....	.33
Hungary	....	.34	.32
Austria	5,313,000	.56	.21
Roumania	482,600	....	.18
Spain	....	....	.17
Sweden	1,677,672	.02	.09
Russia	21,500,000	.01	.032
United States (1905-6)	12,000	.007	.0001
United States (1906-7)	128,650	.0093	.00086

FINANCIAL RETURNS FROM PLANTING.

The financial results to be obtained from planting depend very largely upon the locality and market. In sections of the country with ample rainfall and extensive natural forests, and where natural reproduction can be secured, it will not, for the present, pay to plant. Where timber is in great demand for all purposes and the natural forest is limited in extent, planting often pays extremely well.

For example, in Forest Service Bulletin 37, The Hardy Catalpa, the following returns are figured for some of the plantations examined:

	Net return per acre.
Hannewell plantation, 18 years old	$14.78
Munger plantation, 13 years old	15.01
Farlinger forest, 21 years old	12.65
Yagge plantation, 12 years old (yearly)	7.25–21.55

These plantations are all in Kansas and the returns shown are those for each acre each year.

In Forest Service Circular 145, Forest Planting on the Northern Prairies, the following statement is made:

> A single row of cottonwood trees planted 4 feet apart along the public highway has been known to produce 46.9 cords of fuel per mile in seventeen years. At $5 per cord this would have a total value of $234.50, or an average annual value of $13.80.

In the same circular the following statement is made in regard to white willow:

> For this age (twenty years) cottonwood groves average 560 trees to the acre, and yield 3.56 cords of wood a year, while white willow has 1,700 trees to the acre, averaging 3.42 cords. From this comparison it will be seen that what cottonwood gains in rate of growth in the individual trees is more than com-

pensated for in white willow by the larger number of individuals to the acre. As a lumber tree the former produces an annual net return per acre of $10.57. As a post tree, the latter produces a net return of $24.01.

And with regard to Scotch pine the following statement is made:

The maximum annual height growth attained in any one grove of this species was 3.75 feet and occurred between the age of 7 and 8 years. The trees were as high in two of the groves measured at 15 years as in another grove at 21 years. The difference in growth seems to be accounted for by the difference in character of the subsoil. In the former two it is sandy; in the latter it is loam or clay. The yield for the Scotch pine groves is estimated to be equal to an annual net return of $13.35 upon the upland as against 13 cents in boxelder, $1.71 in green ash, $0.61 in silver maple, and $2.21 in cottonwood.

Table III gives a comparison in rate of growth and yield between our available data and those for the same tree grown from the best quality of soil in European forests:

TABLE III.—*Height.*

Age.	American.	European.	Difference.
	Feet.	*Feet.*	*Feet.*
5 years	3.1	3.1	
10 years	13.3	7.9	5.4
15 years	24.4	16.2	8.2
20 years	31.4	25.4	6.0

TABLE III (*a*).—*Yield in cubic feet per acre.*

	Age.	Cubic feet.
	Years	
American	17	2,628
European	20	2,349
Difference		334

This table, while very incomplete, tends to show that, grown in America, Scotch pine 17 years old yields 334 cubic feet more per acre than the same species at 20 years of age when grown in Europe, assuming, of course, that soil conditions were the same in both cases.

In Forest Service Circular 81, Forest Planting in Illinois, the results of a study of a large number of plantations are given:

Hardy Catalpa. A 20-year-old plantation had material on it worth $449.50 per acre.

The material on a plantation of European larch 30 years old was valued at $386.31 per acre.

A 49-year-old black walnut plantation was valued at $396.72 per acre.

A 35-year-old silver maple plantation was valued at $96.74 per acre, and other plantations showed good returns on the investment in land and the cost of starting the plantation.

In general, it can be said that forest management as an investment will pay under ordinary conditions of market and in sections where forest growth is fairly rapid. The experience of older countries proves that it pays extremely well. With wild woods in this country it is often possible, by keeping out fire and by using a little care in logging, to insure a second crop on land which would otherwise be sold at an extremely low figure or revert to the State for nonpayment of taxes. Every lumberman is willing to assume that stumpage prices will increase, and timber is bought in large quantities with this end in view. This makes it advisable to grow as well as to buy timber to hold for future supply.

In planting the same is true. Land of little or no value can be made to yield good returns. A forest crop needs little attention and only a small outlay after the initial cost of starting. A farmer or lumberman can therefore with slight effort start a future crop which will then very largely look after itself. Forest planting has not yet secured the attention due it, not only as a necessity—if our timber supply is to be perpetuated—but as a profitable investment to the farmer or timberman.

MEASURES TO BE TAKEN BY PRIVATE OWNERS TO INSURE A TIMBER SUPPLY FOR THE FUTURE.

It is, of course, apparent that the perpetuation of our timber supply depends upon the proper handling of government, state, and private forest lands; not only that a second or future crop be secured, but that much greater ones will result. This has been done abroad and can be done in this country. Each holder must manage his lands in a rational and conservative manner. The Government must not only manage its own lands wisely, but must aid States and private owners by information and assistance; the State must aid the individual or company by wise and just fire and tax laws, so that lands will not be stripped of their timber to revert to the State for nonpayment of taxes; the private holder must so cut his land that a second crop and a better one will result.

One of the chief reasons why private owners have not more generally practiced forestry is that they have had a very vague idea of what forestry means, and of the benefits that might be expected to result from its practice; and many have still a very vague idea of what should be done to insure future crops. As has been pointed out, the method of forest management must, in every case, depend on the section of the country and even on the specific tract. In fact, it very often happens that conditions are so different over a comparatively small area that several silvicultural systems must be followed.

Yet there are certain peculiarities common to any forest region. Thus, in certain portions of the yellow-pine belt of the South (loblolly and shortleaf lands), if fires are kept out and from two to four seed-bearing trees are left on each acre, a fine stand of young trees will be secured. In the pine region of the Great Lakes, the brush, composed of poplar and wild cherry, comes in so soon after cutting that it takes several years for white pine to regain a foothold. In the southern Appalachians it often happens that the tree most desired in the reproduction is the most valuable one for lumber, and is so scattered that the logger feels he must take every one of that species and leave the less desirable kinds to seed the ground. The same thing is true in the Douglas fir forests of Washington and Oregon, and in the spruce and fir forests of Maine. In each of these cases inferior trees grow with the superior ones, and when the latter are cut the inferior are left in possession of the ground. In some cases it is necessary to destroy the inferior species, while in others careful cutting will result in a renewal of the desired kind. There is in every case a cheap and effective way of working out the problem.

A timber-land owner with property worth $50,000 should not hesitate to spend from $2,000 to $3,000 for the services of a forester in order to find out the best way in which to manage his lands. The owner of a small tract can get aid from the Federal Government and from the States either free or at a very slight cost.

WHAT THE STATES SHOULD DO TO PERPETUATE THE FORESTS.

By Filibert Roth,
University of Michigan.

SUMMARY.

Aside from their economic functions forests have certain peculiarities as property which necessitates the passing of special laws for their protection. The chief of these peculiarities are:

1. *The time element.*—It may take one hundred years to produce a finished crop. Hence continuity of purpose and treatment are necessary.
2. The growth of each successive year on any one acre is held for years and remains as visible and taxable property. Hence there arises the common and wholly unjust practice of repeated taxation.
3. Timber tracts should be large in order to permit the most efficient management and utilization.
4. Forest land is usually cheap land. It is the tree growth which makes up the large part of the property.
5. Forests are most extensive where agriculture least succeeds, and where, therefore, there is a sparse population.

The state action which is essential for the perpetuation of our forest resources should follow along the main lines which experience has elsewhere shown to be essential. They are:

1. *Forest legislation.*—Proper forest protection is indispensable if private owners are to put timber land upon a permanently productive basis. The States must enact laws which result in effectually preventing forest fires. Much of the expense for fire protection may justly be placed upon the forest owners, but the State must safeguard forest property and provide the machinery for enforcing laws for the prevention and fighting of fires. The methods of taxing forest lands should be so modified as to encourage holding them until the crop is fit to cut or another crop is produced.
2. *State forests.*—These should cover all the rougher and poorer lands in every timber State where sufficient national forests to protect watersheds and maintain a timber supply do not exist. There is especial need that in many cases the States should buy up large areas of cut-over land within their borders and maintain them as forest reserves. New York, Pennsylvania, and Wisconsin have already adopted this principle on a considerable scale, and other States are beginning to apply it.

In discussing the subject of forestry as the care of the woods of our country, the questions constantly come up—

"Why do you ask for legislation and other state action?"

"What is there about the business of forestry that justifies such action or makes such action desirable or necessary?"

"Is forestry of such great importance to the people at large?" or

"Is it such a peculiar business that it can not get on without state action?"

These questions are pertinent; they must be answered before suggestions for state action can be considered. Briefly it can be said that forestry asks for no bonus or special favor; it is an honest, paying business, and merely asks for the "square deal." Forestry is of vast importance to the welfare of our people; it ranks fairly second to agriculture in most of our timber and mountain States.

Some of the laws of the States are positively inimical to forestry; they make forestry as a business impossible, chiefly through unjust taxation and an utter lack of protection of rural property. These laws were mostly framed when the very word forestry was almost unknown in the country, and, therefore, without any bad intention, they left out the consideration of forestry as an important industry.

The following somewhat categorical statement will help to make this clear:

I. REASONS FOR STATE ACTION.

(a) THE IMPORTANCE OF FORESTRY TO THE PEOPLE.

1. *The timber supply.*—The rapid development of the iron and steel industry and the substitution of metal, stone, brick, tile, and cement for wood somewhat misled most people into the belief that the importance of timber in the household of the nation was on the decline; that we would soon be able to do without wood, and hence without forests. The fallacy of this notion is fully illustrated in another chapter of this report. We use more wood than ever, and we now realize as never before that wood is fundamentally necessary to most of our industries to-day, and that with the depletion of coal and iron (both in the reasonable future) wood, again, must form one of the principal bases of man's comfort, of his very existence. For timber may be grown always, providing we do not destroy and lay waste the earth beyond the point of recovery, but coal and metals are mined and sooner or later give out.

As stated elsewhere, in Europe, where the per capita consumption of wood is only about one-sixth what it is with us, every State that has less than 35 per cent of its land in forest is an importer of wood and timber.

The price of timber for more than one hundred years has been more uniform and has increased more regularly than that of any other raw material. This is true not only of our country but is true of all parts of the civilized world.

Wood is used so universally in every household that excessive prices, like excessive prices in bread, react at once and seriously on the welfare of all the people.

2. *The use of land.*—In the Old World, as well as with us, millions of acres of land that were once cleared of forest and tilled have been abandoned by the farmer. In the New England States alone the census of 1900 found that between 1880 and 1900 fully 40 per cent of all tilled land had been abandoned. The tendency of modern agri-

culture is to farm intensively all good lands and lands favorably situated (about cities) and to withdraw from the poorer regions. The importance of this phase of the problem varies with different States. It means little to Iowa, where 95 per cent of all land is good agricultural land, but it means much to the Lake States, the Appalachian and New England districts, and the South, and means still more to the States of the great mountain region of the West, where many millions of acres are at too high altitude to warrant any farming, even if it were otherwise possible. All of these lands can and should be occupied by the forest, and by the use of these vast areas the forest will make a crop which will mean hundreds of millions of dollars to the people of these several States.

3. *Forest and water supply.*—The irrigating States of the West depend to a large degree on the forest to secure to them the water supply on which their agriculture is based. But even the farmer of the Central States experiences a continental climate where, every year, hot, dry spells, accompanied by severe, drying west winds, injure or destroy part of the crops. A well-distributed forest cover is the only remedy (aside from tillage of the soil) which can ameliorate these conditions. It is demonstrated by experiment that this action is of value, and there is to-day no doubt that the presence of such a forest cover frequently decides between a modest crop and an utter failure. It is here not a matter of heavy precipitation or other extraordinary action; it is merely the difference between much dry wind blowing freely over the land and the same dry wind checked locally from field to field by the scattered wood lots and the larger bodies of timber.

The influence of forest cover on the flow of streams and the general distribution of the water supply of any region is to-day universally conceded. But such an influence is of enormous value to the people of most of our States. Nor is this all; this value is on the increase; the development of water power and water transportation, going on all over the civilized world, is making this action of the forest one of first magnitude.

4. *Forest and erosion.*—The question of erosion is of such fundamental importance to every people and in every State that it well deserves special consideration. The farmer of Iowa or Mississippi may care nothing for the forest to supply him with timber, he may be indifferent as regards his crop or water supply, but he can not afford to see his land washed gradually but steadily into the sea.

The injury due to the gullying and washing of our lands is still too little appreciated. Even in the Lake States, where we have always been told about the low gradients of our river systems and the consequent safety against erosion, we lose thousands of acres of fertile land every year, as well as the choice top soil of many thousands more. This loss is enormous; it is permanent; it makes for waste land and for desert. The forest cover, properly distributed, is the only practical means of preventing it. With the experience before us of the Mediterranean countries and the sad stories of the Chinese Empire, showing two thousand years of steady deterioration of millions of acres of land, the gradual driving from the land of millions of people, and the final dissolution of once powerful nations, surely we, the enlightened people of the twentieth century, have little excuse for our indifference.

5. *Forest and æsthetics.*—Man loves the woods. The throng of the city on a summer day is not about the piles of hewn stone and brick or brownstone fronts; it is out to the woods to enjoy the shade and beauty of the trees. This is not new; it is not due to school influences or any other artificial means; it is instinctive, rooted in the very nature of man. The traveler who finds southern Michigan to-day a "pretty country," does not mention the red barns nor the "bill-posted" back yards which the towns offer to the passing train; it is the woods, and the woods chiefly, which make this southern Michigan, like many other parts of the Union, attractive to him. The æsthetic value of the wood lots of Michigan is worth many millions of dollars, which are capable of being lost by the removal of these woods.

6. *Forest and ethics.*—Generally we preach one code of ethics for the ordinary man, another for the "extraordinary" man, either on top or at the bottom of society, and usually no code at all for the State or Commonwealth. We are getting over this Machiavellian habit, and surely, if it is proper for the ordinary man to leave to his children a decent heritage, to leave the farm as good as he found it, it is equally the concern of the State and of us individually, the people of to-day who make up this State, to leave it in as hospitable and beautiful a condition as we found it, and to avoid, at least, serious devastation. The devastation of the forest cover is one of the most conspicuous of all. The logging of the mature white pine in Michigan was good, sound business; the conversion of millions of acres of forest into blackened stump waste was a serious and unwarranted mistake; the continued burning and devastation of these same lands by a prosperous people is nothing less than a crime.

(*b*) PECULIARITIES OF THE FOREST.

In legislation or state action the peculiarities of a business necessarily require special consideration. Our attempts at railway legislation illustrate this perfectly. The forest—and with it the care of the forest, or forestry—has its peculiarities, and some of these are so very conspicuous and important that Dr. B. E. Fernow, in his excellent book, The Economies of Forestry, emphatically speaks of the forest as a property "sui generis," or peculiar enough to go into a class by itself. This same idea has served as basis of forest regulation and legislation in Europe for centuries past.

The following are probably the most important and most self-evident of these peculiarities:

1. *The time element in forestry.*—It takes many years to produce a finished crop. Timber in Germany to-day is cut at an average age of about ninety years.

2. The growth of each successive year on any one acre, i. e., the part which corresponds to the farmer's crop of the same year, is held for years, and thus remains on the land as visible and taxable property. To illustrate: Suppose a farmer plants 20 acres with corn and 20 acres with pine in 1908. In October, 1908, the corn crop is ripe, is harvested, and is sold, fed, or eaten probably before April, 1909. This crop is not taxed at all. The field is assessed as land and as land only. In October, 1908, the little forest trees, too, have

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ripened a crop, one of wood. It is a small crop, but it is a crop, and it stays on the land. By the year 1940 the cornfield has been planted 32 times and has furnished 32 crops, and the crop has never been assessed or taxed. By the year 1940 the pine trees have also made 32 crops, and all 32 crops are still on this plantation of pine trees. But now the assessor, according to our law, must assess this plantation at cash value, or as much as a box maker or wood dealer could and would give for the pine. In 1950 the pines are still there and each year's growth or crop is added and the assessment raised accordingly. If the two fields are alike in quality, the cornfield continues to be assessed at, say, $50 per acre, but the pine field is assessed $50 for land and $50 for the pine, or $100 in all. This continues up to the time when the pine is cut or harvested, say at eighty years. When that crop of pine is 75 years old the farmer is really assessed on the land and also on 75 successive crops, i. e., the growth of seventy-five successive years, on all of which he has paid taxes before and on a large part of which he has been taxed repeatedly. But this method of taxation is prescribed by law in practically all States of the Union.

3. A large part of the timber crop may actually be used (cut or sold) long before the forester declares the crop ripe, i. e., long before it is the best business to cut it.

As pointed out above, the pine could be cut for wood at twenty, for pulp at thirty, for box material at forty years, and yet it is really best for the owner and indirectly best for the people and the State that it remain and grow into saw timber, or to an age of 100 years.

4. The size of the woods has much to do with the value of a forest property, and European people have found long ago that it is bad policy to allow timber lands to be cut into too small areas or parcels. The reasons for this are many. The woods, the trees, do better in the interior of a 100-acre lot than a small 5 or 10 acre lot where wind and sun can dry out the ground. In case of fire or storm the man who owns only 10 acres of woods may lose everything, but the man who owns five tracts of 600 acres each is not likely to lose more than a small part of what he owns. The man who has only one or two logs of oak to sell in our town has to give them away or even hire a man to take them away or cut them into firewood; the man who has 200 oak logs to sell can readily find a buyer at $15 per thousand feet b. m. The experience of Europe, and of our own country as well, clearly shows that as soon as a forest is cut into small tracts it is apt to be cleared or devastated.

5. The long period between sowing and reaping necessitates in forestry that there should be continuity of purpose and action. For this reason the forests belonging to States, cities, and towns, or all large woods under direct state control, have fared well, while most private forests, especially the smaller holdings, fare poorly. This fact led, centuries ago, to more or less state interference and control of private forests, a control which even at the present day is rather on the increase than decrease among European people. The common use of the wood lot reminds us of the cases so often met with in this country. The father takes care of the wood lot, saves the large oak, ash, and other valuable trees, uses the inferior material, and in this way stores up values fully as good as bank deposits. The son, who has early learned "better" (?) living, has a poor crop, he needs

money, and cuts the small forest. Then for a while it does not bring in any income, he tires of holding and waiting, and clears it irrespective of the future value of the farm. This case is thoroughly human, it will always be so, and only the strong hand of law can compel the son to regard the wood lot as property of a peculiar kind, from which he may never use more than the growth or real crop, and which, owing to its relation to the rest of the people, he may not clear or devastate without special permit.

6. The land used in forestry is usually cheap land, and it is the tree growth which makes up the larger part of the value. Thus the state forests of Württemberg have for years brought a net revenue of over $4.50 per acre per year. Capitalizing at 3 per cent, they are worth $150 per acre, but the land itself would be dear at $30 per acre and would not be worth $10 for agricultural purposes. Probably half of all the forest land of all central Europe could not be farmed permanently, but would become waste land in time if allowed to be cleared.

7. The capital used in forestry is large, and large holdings are desirable. The amount of labor is small. Thus $2 per acre a year is a good allowance for expenses even in Germany, while in farming, even with us, $10 per acre is but fair.

8. The net returns in forestry are rather large and are safe, and, considering the quality of the land for other purposes, these returns are often astonishing. In our country this is evidenced by the large crops or stands of timber in some of our mountainous districts and on the large expanses of sand, both North and South.

In the Old World much more exact data are available. Thus the state forests of Baden, Württemberg, and Saxony, aggregating over a million acres, have for years exceeded $4 per acre a year of net income. When it is remembered that good farm lands over a large part of the lower peninsula of Michigan are unable to produce this as cash rental, the showing surely is extraordinary.

9. The forest, unlike most agricultural crops, improves the soil and prevents its washing. The forest can use poor lands and frosty districts or situations which are otherwise valueless. This with its power to regulate stream flow and water distribution generally has forced the states of Europe into a recognition of the conception of the "protection forest," the forest which is valuable chiefly because it protects the land and prevents waste and desert and general injury to the people or state. This conception is general and fixed, and its use is extended more and more throughout Europe. Interesting is the fact that it was this conception of the protective value of the forest which decided the Congress of the United States to pass the first really important measure in favor of forestry in the New World, namely, the establishment of the national forests.

10. The forest is usually most extensive where agriculture least succeeds, and where, therefore, there is the sparsest population. But the forest can not be locked up, it can not be inspected in all its parts at a glance; on the contrary, the forest offers seclusion and a hiding place for the evildoer, and it is therefore one of the forms of property which needs specially rigid legislation and enforcement of law for its protection. This fact was recognized early in the development and settlement of central Europe. As early as the year 1200

the local laws governing the conduct of people in the use of the forest dealt with this fact, and trespass in timber, changing of boundaries, and setting fires in the forest, etc., were all treated as special offenses. And universally it was believed necessary to provide regular guards to protect the forest, a fact entirely overlooked and neglected in our States.

II. WHAT THE STATES HAVE DONE AND ARE DOING.

ABROAD.

In central Europe, where forestry really had its beginning, the states, as represented by the ruling princes or monarchs, began as early as the year 1000 to give special consideration to the forests. The compilations of local laws, known as the "Sachsenspiegel" (1215) and the "Schwabenspiegel" (1273), recognized the importance as well as the peculiarities of forest property. As early as 1304 Emperor Albrecht ordered the reforestation of devastated areas in the Palatinate. In France the laws of 1346 organized a regular state forest service, though more or less of this organization had existed for over a century. As the states of central Europe gradually took on more definite form, the numerous local laws, orders of the nobility and the clergy, the regulations of town and village, were replaced by regular state laws, or laws having effect alike in all parts of a given state. Thus, for the little state of Württemberg the law of 1515, revised in 1641, remained state law until 1879, a period of over three and one-half centuries, and is practically in force to-day. In Bavaria the law of 1568, revised 1616, remained in force until 1852, and forms the body of the existing forest law of that state. Similarly in Baden the laws of 1614, which replaced several special laws dating back as far as 1448, remain in effect to-day. In Hesse the local laws, promulgated as early as 1338, by free cities, cloisters, and certain of the nobility, and having effect only on the territories belonging to these several powers, were replaced by the laws of 1520, 1605, and 1628.

In Saxony the laws or "Forstordnungen" of 1560, 1585, and 1598 serve the same purpose and affect the forests of the prince, the nobility, and all subjects. In France the law of 1669, as part of a general system of progressive legislation, compelled all owners of forests to obey certain regulations, believed by the great Colbert to be for the welfare and power of the state. These laws were not mere decorations or a screen for game preservation; they were plain business and proposed to avoid the devastation of the forest, to prevent scarcity of raw material for shop, mine, and marine, and to keep the useless lands covered with a useful growth. They were too severe, and were abolished by the revolution; the state forests were sold and destroyed, the private forests devastated. In 1801 a new law was put in force and a forest service organized. In 1827 the old law of 1669, considerably modified, to be sure, was reestablished, and since that time France, though a republic for thirty-seven years, has "tightened" in the matter of forest legislation.

Even Russia with its enormous forest wealth, its vast stretches of unexplored and unexploited woods, has seen fit ever since 1645 to pass special laws with regard to forest property and its use and protection.

These laws of the different European States were a matter of development; they represented even in their first form the experience of centuries, and accordingly they have stood the test of time and prove of value to-day.

Generally these laws cover the following principal points:

1. *The ownership, purchase, sale, and management of forest property by the State itself.*—Thus every State of the German Empire owns and operates forests. The same is true of France, Austria, Hungary, Scandinavia, Russia, and other States. A notable exception is Great Britain, which owns hardly any state forests at home, but has one of the most extensive state forest systems in India and other colonies.

In Germany the States own 33 per cent of all forests, in Austria 7 per cent, in Hungary 15 per cent, in France 12 per cent, in Russia 66 per cent, in Sweden 33 per cent, and so on. These state forests are in numerous scattered parcels, and are cared for by a regular service, an organization made up of technically trained foresters assisted by a corps of protective men or guards. The expenses and income are handled by the treasury department of the State, the management is for profit, and the net income reduces by just that much the tax burden of the State. In spite of all attacks on the policy of the state forests, which were especially severe during and after the French Revolution, this policy is thoroughly established in every civilized State of Europe; it is fully appreciated and approved by all people, and the state forests are steadily increasing in almost every State. The indications are that the future of all large holdings in Europe lies in their ownership by the State itself or by corporation, city, or village under direct state control.

2. *The supervision or control of forest property by the State.*—This varies with different States; includes generally all forests belonging to cities, villages, and other public bodies, but in a number of States it is extended also to all private forests or at least to private forests under certain conditions. Usually this supervision tries to secure to the forest a businesslike care and prevent every form of misuse; and in most cases it prescribes the employment of technically trained men, the approval by state authority of the plans under which the forests are managed, and state inspection.

3. *Laws forbidding the further clearing of land or removal of the forest.*—This is really the oldest form of state action which attempts to conserve the forest cover. In some form or other laws of this kind date back as far as the year 1200, a time when the want of accessible wood material made itself felt at least locally for the first time among Teutonic peoples. These laws, which were practically general at one time, have been much modified; in some States, like Saxony and Prussia, they have been practically abolished; in others, like France, restricted to forests, taking on more or less of the character of protective forests. Generally these laws apply to all forests and provide that the owner of a forest can not clear without securing a permit from the state authorities.

4. *Laws forbidding devastation or misuse of the forest.*—These laws also are very old, were almost universal two centuries ago,

are quite general at present, and like the preceding they apply to all forest properties. These laws call in the police function of the State only when there is evident misuse, but in this case give ample power to the authorities to interfere for the safety of the property; they have been much modified and in some States have been abolished entirely, but on the whole seem still firmly fixed with a tendency to extension through a more liberal interpretation of the idea of the protection forest. To illustrate their application: A private owner has 100 acres of woods in Baden. This forest is not really under state supervision like that of a village; he can make his own plan, hire a forester or not; he does not account to the State for the material he cuts, and is not subject to the state forest inspection. His forest is free, it is his. But he can not clear an acre without permission from state authorities, and if a state forester or rural police discovers that he is overcutting the woods seriously, to the extent of timber devastation (something like a modern Michigan logging job), the police reports the case to the authorities, an investigation is made, a hearing is had, and if the owner can not make a good case, he is warned, his cutting is stopped, he is ordered to reforest, and in extreme cases the forest may be placed for a period of years in the care of the local state forester, the State paying the owner such sums or giving him such materials as are taken from the property, and deducting the expenses which are involved in the care of the woods.

5. *The purchase and reforestation of waste lands and devastated mountain lands.*—This form of state action carried out, especially in France, the German States, Austria, and Switzerland, recognizes: The necessity of state action with regard to such lands; the necessity of forestry in the reclamation of such lands, and the inability of the private individual, the village, and even the county to do this work.

Centuries of experience; the gradual deterioration of millions of acres of land into wastes, and the accompanying evils of poverty, crime, and general lawlessness; the disturbance of stream flow, and flood, and drought—all these have taught the people and the states of Europe the necessity of this line of action. And to-day states like France, and Prussia, and the other German States, and even little Switzerland, have a regular appropriation for the purchase of such areas and for their reforestation. This work has become one of such magnitude and importance that it has resulted in the development of a definite state policy, in broad-gaged, farsighted legislation, and in the expenditure of enormous sums of money. The state usually appears as a buyer; it is represented at the auction sales of property; it buys in the land that is of little value and that is in danger of devastation. The states of Europe do exactly the opposite of what we do in most of our States, where the poor tax lands, etc., are crowded on the market at any price and to no purpose. In certain cases, as in the mountains of France and Switzerland, the state exercises its right of eminent domain and takes the lands on the principle of the greatest good to the greatest number.

6. *Adaptation of the tax laws to the nature and needs of forestry as a business.*—Though the methods of taxation of forest property are by no means uniform or alike in all States, yet they are everywhere so adjusted that forestry as a business is possible and they

do not form an inducement to clear away the forest. Like other forest laws, they are a matter of centuries of trial and adaptation. Up to recent times forests were generally taxed on the ordinary plan of a "ground rent," or soil tax, just as the farms are taxed in our States. This form of taxation is ancient; it taxes the land only and is therefore based on what the land can produce or what it would bring if sold. In recent years this form has given way extensively to the income tax, which is based on the net income which is derived from a piece of property, and the tendency throughout Europe is toward this form of forest taxation as the only scientific and just form.

7. *The protection of the forests by special laws and by a rigid enforcement of law.*—Not only is the forest property dealt with as a property deserving the attention of Government, but all its peculiarities—the extent of the areas, the difficulty of seeing or finding the damage, the greater difficulty of catching the evildoer in the act, the serious danger of fire in the forest—are fully recognized in the protective laws of practically every state of Europe.

But what is far more important, the state action does not stop here. It is not content, as it is with us, merely to pass laws for the protection of the forest, but provides for the enforcement of the law, and it does this unstintedly and at all times and in every nook and corner of the state. There is no confusion of authority, no shifting of responsibility; there is no game warden shifting responsibility on a firewarden, and the latter claiming lack of authority; there is no $50 expense limit for a whole township, as is the case in Michigan. On the contrary, when a fire breaks out in a French or German forest, the citizens are called out, the police and foresters direct the work, and the fire is fought till extinguished. It is treated as a common enemy, and fought by the people regardless of effort, until checked. The people are not paid $2 per day and thus tempted to have more fires, as is the case with us, but they are compelled by law to help and to work. Thus the village, the town, the county, and state all hold themselves strictly responsible for the protection of forest as of other property, and the taxpayer in a German state or in France knows what he is paying his taxes for.

8. *Laws regulating the traffic in timber.*—This is tariff legislation, is quite general, and is based on the same economic principles as is other similar action. The forests of the state, forestry, and also the manufacturing interests are usually considered.

9. *Special and clearly-defined treatment of timber or the products of the forest on all public systems of transportation.*—By this means the timber market, and with it the timber business or forestry, is on a simple, well-known, and stable basis as far as transportation is concerned, much to the benefit of forester and consumer.

10. Laws relating to "protective forests," i. e., declaring that large areas of woods have such critical influence on the welfare of the surrounding country by regulation of water supply, etc., that their management becomes a matter of public concern, and warrants police or state interference and supervision.

11. Last and least come a number of various state measures which may be grouped under the general head of "encouragement" laws. Strangs to say, this line of state action is rather new in Europe, and it varies from state to state in kind, extent, and consequent

value. In keeping with the modern belief in education, laws of this kind are becoming more numerous. In some cases the state provides, free of charge, lectures and advice to landowners, free plant material, etc.; in other cases it goes further and assists with money and men in projects of reforestation; and in several of the states encourages such reforestation by relieving the owner of paying taxes for ten to twenty years or usually for such a time as is necessary to make the trees of a plantation of some market value.

IN OUR COUNTRY.

When we remember that the per capita wood consumption in the United States is six times as great as that of other progressive people; that our national consumption has reached the enormous amount of about 40,000,000,000 feet of timber; that most of our forests are in private hands; that they are largely devastated, and that the remaining supplies are going just as fast as human ingenuity can convert them into marketable goods; and that there is no reliable, satisfactory, adequate source of supplies for this large people to draw upon in the future, the needs for state action must be apparent to everyone. And yet, compared with the magnitude and the seriousness of the problem, all of our state action appears as nothing.

State action in our country thus far has followed four somewhat distinct lines: (*a*) Protection of the forest against trespass; (*b*) protection of the forest against fire, as a special enterprise; (*c*) promotion of forestry by various means; (*d*) the establishment of state forests and forest organizations charged with the care of forests.

1. The laws against forest trespass form part of the general code of each State; they were carried from State to State and were originally borrowed from the Old World and modified to suit. In our older States these laws have been in force a long time; they are generally quite simple and direct, and usually prescribe rather severe penalties—one of the many reasons of their nonenforcement. Thus, for instance, in Michigan, according to section 11749, a case of willful or criminal trespass, though it consist merely of cutting $30 worth of timber, can be punished by five years in the penitentiary and a fine of $2,000.

These laws are not uniform; they differ in form and severity for different States, but in practically all States they are quite sufficient. But they are not enforced, and never have been in any State. The machinery for their enforcement is wanting. If the owner or his agent catches a man taking timber, he can prosecute through the proper office, bring the case into court, and if he can get the jury to convict, he can get the evildoer punished. It is a matter between owner and court and not one of police.

For a farm owner who occupies his 160 acres, this may be quite sufficient, but for the man who lives in Detroit and owns 25 different parcels of forest scattered over several counties of the Upper Peninsula, this machinery does not suffice, and in his case he must either provide his own police or leave the law unenforced. Neither town, county, nor State concerns itself about the matter, though all three share in the taxes which are paid by the forest owner.

This is one of the causes of the peculiar attitude of the local people toward the nonresident forest owner. Though, in truth, these resident people often make their living from the tax money of the nonresident, and though the latter contributes toward every rod of road and every schoolhouse built, and other improvement, yet he is treated as if he were a wrongdoer, is taxed unmercifully, and, in addition, a trespass on his land or forest is excused and it is almost impossible in many places to get conviction. This has led in most forest States to peculiar conditions.

Thus in Michigan and other States the State itself gets no protection from the local authorities. The system of government is entirely perverted, the sheriff and the town official may even share in trespass on state lands and the State is driven to adopt a makeshift police system in the form of state trespass agents, whose business it is to guard the interests of the State.

We have here literally one part of government of the State organizing against another, or at least to do the work of the other—the part properly established by constitution for this purpose and elected under this constitution by the people. But no one is obliged to do his duty. And here lies the weakness of all forest protection by the State of Michigan as elsewhere.

That this lack of protection against trespass has not helped to conserve forests is easy to see. The owners of forest lands have been involved in endless litigation. Where the situation has been very bad they cut the timber. In many cases timber stealing was hidden by setting fire to the slash and thus wiping out the telltale evidence of cutting.

Generally speaking, the trespass laws have helped; they have protected against large and continued trespass, but their general nonenforcement by the proper authorities themselves has done serious and lasting harm to forests and forestry.

2. Usually with the first code adopted by each State came laws, derived like the laws on forest trespass, dealing with the prevention of fires in forests and on prairies. Like the laws on trespass, these earlier efforts are simple, direct, and severe. Thus in Michigan, as early as 1846, the law provided a penalty for willfully burning the woods of another, amounting to as much as five years in state prison and a fine of $500. Quite early, and in some cases as parts of the first protective act, came provisions making the fighting of forest fires a special duty of the supervisor, the justice of peace, the highway commissioner, or some other official, giving these officials power to call out the citizens and making it obligatory, under severe penalty upon the citizen, to obey such summons and to help in the fight against fire. The responsibility of the local authorities was thus clearly recognized at an early date. But there was a penalty prescribed only for the citizen and not for the officer, and so the officer found it to his political interest never to call people out.

Thus these laws (even more than the laws of trespass) remained dead letters. The difficulty of catching the evildoer, together with the ease of finding excuses in having to clear land, burn brush, cook food on camp fires, etc.; then also the matter of accident, the pipe, cigar, match, and torch, all allowed in the forest at any time and season; the general permission of anyone to travel, camp, hunt, and fish on other people's lands; all these made it practically impossible for the owner or his agent to bring the matter into court and secure conviction. And even if conviction were obtainable, it would have been of little value, for it is prevention of fire and not merely conviction of the firebug that is wanted. And here again State, county, and town did nothing; and with this the sense of individual as well as corporate responsibility disappeared. No one raised a hand, and the evildoer, the lone, shiftless do-nothing, who maltreats his family and his animals under the guise of being a pioneer settler, and who is ever ready to see the woods burn, could fire it to his heart's content. He could vent his spleen, or spite the thrifty neighbor; he could right the wrongs which his vicious imagination made him believe that he had suffered at the hands of the lumber company, and he could tell of the "two men with guns" whom he saw, or the "city guys" who camped there, or invent any other of the multitude of cock-and-bull stories which are circulated regularly and given emphasis by the press and the townspeople who know precious little of the situation.

It was in this way that the hundreds of fires have been started every spring for the last forty years, and it is in this way that hundreds of fires spring up in dangerous dry summers like that of 1908 and rapidly eat up the forest cover over millions of acres of land.

After a number of really great calamities, like the fires of 1871, 1881, and 1894 in the Great Lakes region, where hundreds lost their lives and thousands were made homeless, and where the damage ran well up into the millions, the situation became positively intolerable. The people clamored for action, and the legislatures reluctantly enacted a series of laws, all of which were more or less modifications of the old fire-fighting laws already in existence, and collectively perhaps best termed "firewarden" laws. Like the trespass agents and game warden laws, they are a makeshift, a duplication, and interference in what should and could be the proper administrative body of the state government. The Michigan law, copied and modified after that of New York and Minnesota and again copied by Louisiana, etc., illustrates this phase of state action. The State had a good, simple, though somewhat incomplete, forest-fire law, with a provision which made it the duty of the supervisor, justice, and road commissioner to call out the people and fight forest fires. Beyond this the State never spent a cent in protecting its second greatest natural resource and its second industry.

After enormous losses and years of agitation, the legislature in 1903 made the state land commissioner a state forest commissioner (and this in spite of the fact that he already was a member of the state forestry commission), with power to appoint a state firewarden. This man, with a salary of $500 a year, had authority over the supervisors who were thus once more legislated into the firewarden job. The earlier law was repeated in its main features, but the people were to receive pay for fighting fires, and the sum total spent in any one town should not exceed $50 in any one year, so that if $49 should once be spent the people must be sent home because no more money was available. Of this law the state land commissioner himself, in a public meeting, declared that it was not worth the paper it was printed on.

In 1907 the power of the land commissioner was transferred to the state game warden, who was made fire and game warden, the idea being that this office, equipped as it was by law with deputies scattered over the State, was practically a police body and thus would do better work. But when the writer asked a deputy game warden, on September 11, 1908, if he had any instructions, the reply was negative. Though the whole country was on fire and though every supervisor was by law compelled to fight, it was deemed unnecessary even to issue instructions. Again, no officer is obliged to do his duty.

The utter uselessness of these firewarden laws is amply proved by the fires of 1906 and of 1908 in Michigan; by the fires in Wisconsin, Minnesota, and New York. Aside from the small educational value of the posters, it is doubtful if these laws ever prevented a fire or put one out. The pay provision in these laws is generally conceded to be a mere temptation to build enough fire to get the state money. The forest still remains without state protection against fire.

3. The encouragement laws, or laws for the promotion of forestry in the several States, have so far been chiefly along two lines: The creation of forest commissions and, of late, state foresters, to gather and distribute information, make propaganda for forestry, and act as advisers to the legislature or government of the State; and the encouragement to plant trees or maintain forests by offering a bonus, or by exemption of the plantations from taxation. These laws have commonly been hedged in with numerous useless conditions and are usually considered unconstitutional. They have, perhaps, had educational value, but otherwise they have been of practically no use. These laws have neither planted nor preserved.

4. State action creating state forests or parks, and providing an organization for their care, has been of great and lasting value, and may well be regarded as the only one of the several state efforts which has resulted in unqualified success. Here come first New York and Pennsylvania and Wisconsin; then the smaller attempts of Minnesota, Michigan, Connecticut, Massachusetts, New Jersey, Indiana, etc., all of which have been of value. These state forests speak for themselves. They are an object lesson, and form the nucleus of what some day must be the principal center of state activity with regard to forests.

III. EXISTING OBSTACLES TO FORESTRY, WHICH THE STATE ACTION ALONE CAN REMOVE.

As more or less indicated in the preceding, there exist to-day in every State of the Union certain great obstacles to forestry as a business, and some of these threaten seriously even our present and rapidly vanishing timber supplies. These obstacles offer no extraordinary difficulties; they can be and will be overcome as soon as the legislatures of our States catch the "forestry spirit," which is now so unmistakably spreading among our people. Unfortunately, the legislatures have been reluctant in this matter; they have treated it as of the "reform sort of thing," to be looked upon suspiciously and to be put off for future and better consideration and understanding.

It is a remarkable fact in this matter of forestry, which is a purely economic matter and to the legislator means only the adjustment of law to the needs of a useful and necessary branch of agriculture, that where 90 per cent of our people are agreed that the proper measures should no longer be delayed, we still find the legislatures hanging back. In fact, there are few legislatures of the last five years where even 2 per cent of the legislators displayed any interest in the matter, and still fewer where even a single man could be found who was willing to put his shoulder to the wheel to accomplish what 90 per cent of the people would be glad to support.

Nor is the matter so technical. There are various ways in which the obstacles may be removed, and almost any effort can be modified and improved as time goes on. Good will and good sense are the only requisites.

The obstacles to forestry which state action alone can remove may be grouped under the following four heads: Taxation to the point of confiscation; lack of protection of forest property; personal liberty to the point of license; mistaken policy regarding state lands and the holding of lands by all public corporations, counties, towns, and cities.

1. *Unfair taxation.*—Every owner of forest land in almost every State is agreed that unjust taxation has led to premature and hasty forest clearing. Here again the conditions existing in Michigan, which apply to most of the States, will help to illustrate. In Michigan the distinction is made between the assessment and the rate of taxation, for it is the latter especially which has operated injuriously.

The assessment, according to present law, is at "full cash value" of the property. It assesses the growing crop as well as the land. How this would affect a case of reforestation has already been pointed out. It makes the tree farmer distinct from the corn farmer; it assesses only the land for the latter and the land and crop for the former, besides piling up the assessment all through the life of the trees. This method of assessment, then, is absolutely prohibitive to any effort at reforestation.

In the case of the man who owns and holds a forest already in existence the case is less unfair. He can cut and sell timber, but even here it is in danger of becoming unfair, and it usually does become so in practice, since this assessment in nowise takes into consideration what the property is making for the owner. In the case where the forest is bought merely to lumber it—that is, when only the stumpage is sold—this assessment is fair and correct in principle.

The unfair practices of excessive assessment of the forest and excessive taxation of the nonresident owner, together with the lack of satisfactory safeguards against these, need not here be considered, though these, too, have worked a great deal of harm to the forest.

The total tax rate is made up of state, county, and local (town, highway, school, etc.) tax rates. The first two are usually not high in any State. Thus for 1905 we have for Michigan: state tax, $2.46 per $1,000 of property; county tax, $2.40 per $1,000 of property; township, school, and highway, $10 per $1,000 of property; total average rate for the State, $14.86 per $1,000.

The town, highway, and school taxes (the local taxes) are levied by the local people. The few residents of one of the thinly settled towns levy these taxes, and there is no law to set a limit or maximum, and they build roads and bridges, schoolhouses, etc., whether needed and justified or not. They can make, and often have made, a large part of their living by doing the jobs which consume the local tax. It is argued: "Yes; but they tax themselves as high as anyone." True, but their own little properties represent but a small part of the total property of the town. It is the nonresident who commonly pays 95 per cent of all txaes levied; and it is by working (?) out this 95 per cent that they make their living and the "representative" man or local politician makes his money. What this leads to is well illustrated by the following:

In 1901 the average tax rate of one county in Michigan was over $63 per $1,000 of property; in five other counties it exceeded $40, while in 13 more it exceeded $30. And every one of these high-taxed counties was a timber county, a thinly settled district, where the nonresident, land-owning taxpayer was bled for all he would stand. In some instances the combination of assessment and rate led to the levying of a tax rate amounting to over $100 per $1,000—confiscation in ten years.

For this reason it has been one of the common questions in the timber owner's office, when deciding on where to cut next winter, "How do we fare in ——— Township as regards taxation?" If the answer is "Good," the cut is not made; if "Bad," the decision is, "Then we will locate a camp there." It is not asserted that if the tax rate had been low or reasonable and honest that the forests would not have been cut; what is asserted is this:

If the State and local people had treated the owners of timber honestly and had spent a reasonable part of the taxes in giving the protection which the owner had a right to expect under the Constitution, there would still be more than half of our pinery lands covered by forest. But this was not and is not the case. A certain forest owner in Michigan paid during the last twenty-five years over $600,000 in taxes, and it would be difficult to prove that a cent had ever been expended in the protection or real improvement of this property.

The result of this is also well illustrated by Michigan conditions. As early as 1875 over 9,000,000 acres of land, one-half of the north half of the State, was returned as delinquent or "in soak" for taxes. The owners could not afford to hold the lands, and as soon as the then marketable stuff was cut they let the land revert to the State.

2. *Lack of protection.*—This has been partly discussed above. There has never been any responsibility anywhere. The town, county, and State have acted as if the forest were not property in the ordinary sense. This was and still is especially true of protection against fire. The town officials in most States, as in Michigan, were supposed to act, but they were not compelled to, while the county officials never concerned themselves at all. Even of late years (since 1903) the case has been no better. Now and then a bit of fire fighting is done to keep the fires out of the settlement, but even then there is no head, no method, no responsibility, and in some cases it seems chiefly a matter of earning $2 per day. As stated before, the new law in Michigan has helped nothing, for the very head takes evidently no interest in the matter. Besides this utter lack of responsibility in the execution of law and the fighting and prevention of fires, there is an amount of personal liberty allowed which long ago degenerated into the worst form of license. Everyone, irrespective of character and previous record, is allowed to travel over these lands, to hunt, fish, pick berries, and camp where he

pleases. In this way the woods are overrun by persons unknown as to name and character to any of the local authorities, and have long been the hiding places of the irresponsible and even of the criminal.

During the dangerous dry seasons some of these people are constantly setting fires, but the large areas and the difficulty of locating fire and people make it practically impossible for the few town officers to apprehend the culprits. Again, everyone is allowed to fire in order to clear land; and though the danger of this practice has been long recognized, even in our old fire laws, nothing effective has ever been done to regulate it. Under the pretext of fighting fire, or of protecting property by backfires, thousands of acres are burned over every year. In no case does the law prescribe sufficient care. Even in the driest season, when the cut-over lands especially are far more dangerous than any ordinary saw mill or similar establishment, the pernicious cigar or pipe is in common use; matches are struck and thrown into the dry, inflammable brush; campfires are built without regard to safety; shooting is done without excuse or need; and all these things go on without interference of law.

If some evildoer is actually caught in the act, the right to arrest him is not granted except to sheriff and a few officials who never concern themselves about the matter, and the man is allowed to escape. And even in cases where the guilty party is located, the juries are reluctant to convict except on the clearest proof, and the general record of the person as a notorious firebug is usually disregarded. The result is that, in spite of the fact that there are hundreds of forest fires set every year in the State, the writer knows of not one single case where the culprit has been convicted and punished.

3. *Personal liberty.*—Aside from its abuse in connection with forest protection, personal liberty has been and is held so sacred that the owner of forest properties is universally allowed to do as he pleases. He can cut and slash, burn and devastate, without interference.

It was not until within this year that at last the courts have begun to recognize the right of the Commonwealth in the matter of forest property and the treatment of it. That the misuse of any property is a wrong morally is conceded; that it is so legally is also conceded as soon as the misuse is truly serious or the property is of a peculiar character (railroads, etc.). That the unlimited, unrestricted misuse of forests by their owners was not only a mistake and poor business, but was a serious moral wrong and should have been made a legal wrong as well is just beginning to dawn upon our people.

4. *A mistaken policy toward the holding of land by the State, county, or other public body.*—Here we are concerned primarily with the matter of state lands. With the general craze to get all lands cleared and settled, and with the individualistic mercantile spirit dominating everywhere, it was but natural that the States of this Union should at all times have been eager to dispose of all their lands. That this policy resulted in much harm is now quite generally conceded, and in a few States a radical change of policy, or at least of the laws leading to such a change, has come into existence. Here again the conditions in Michigan serve well to illustrate the workings and results.

From the beginning the State sold, was eager to sell, fairly forced the sale of, all lands given to it by the Federal Government. It sold "cat in the bag" from the first and is selling in this same unprofitable manner to-day. The expense of a real examination was too great, and the faith in an examination by the usual political clique was too small, and so the lands went for what they would bring. For over thirty years thousands and hundreds of thousands of acres came back to the State for nonpayment of taxes (result of bad tax system). These lands cost the State millions of dollars in advertisements and clerk hire; they were again and again sold in the same fashion. To-day the State owns nearly a million acres of these lands, skinned and skinned again, several million acres come up annually "in soak" for taxes, and still the State spends money trying to get rid of them. During the past five years the State sold over 800,000 acres, received about $1.20 per acre for them, and now it is shown by special examinations that these lands had timber enough on them to pay the above sum twice over, and that thus the State gave away land and timber and young trees to the amount of millions of dollars. And what is even more pitiful, the lands thus sold are held by owners just long enough to cut off the timber—to burn them over; then they let them revert. Thus the land policy has robbed the State of millions of money, millions of acres of land, helped in further devastation of the country, and in many cases promoted a form of land speculation which is even worse than forest devastation.

Had the State kept its lands, sold them only on application and at a fair price, and separated all poor lands as forest reserves, it would have received more money, these reserves would now be producing an income instead of causing expense, and the State would be in a fair way to supply itself again with all forms of timber instead of having to import as it now does.

This general policy of "getting the lands on the tax roll" permeates all of our States. The timber counties of Michigan, of Wisconsin, and of other States could have reserved county forests and thus freed themselves from all county and state taxes by holding income-producing properties, and many of our towns could have done the same.

IV. WHAT THE STATES CAN AND SHOULD DO.

From what has been said it is clear that state action is necessary; that the lines of action be few and simple; and that such action should take very much the same form which forest legislation has taken in the older nations.

Categorically, state action should provide for: (1) A rational state land policy; (2) the establishment of state forests; (3) forest protection; (4) rational and fair forest taxation; (5) enforced right treatment of forest properties; (6) continuation of education in forestry and the encouragement of forestry among the people.

1. The State should cease to sell lands and become a purchaser of lands. It is clear that this measure must vary with the State; that it means not the same for Indiana as for Wisconsin; and that in the case of such a State as Iowa it may be dispensed with altogether.

But fundamentally it is good policy for the State to own land, and not only poor land, but good land as well, and especially for it to own all lands which do not promise a truly prosperous condition of settlement. This policy will be fought here, as it was fought abroad, and as it is now being fought locally in our States, by the land speculator, who revels in cheap lands—the natural goods of the land swindler. It will be fought also by the small local business man and the local politician, both of whom want, at any cost, settlement and people to live on, regardless of the ultimate harm to State and county.

As an illustration of the value of the States purchasing and owning lands and forests, the case of New York may serve. The Adirondacks lands were disposed of by the State at about 5 cents per acre; the State began buying back these lands in 1884; it has bought over a million acres, largely culled, at an average price of about $3.60 per acre, and to-day it has a holding worth at least $20 per acre, besides securing to its people one of the finest summering places and one of the beauty spots of the New World—in itself worth all that these lands have ever cost.

In purchasing lands by the States for purposes of forestry, it will be wisdom to buy good forests at good prices, as well as poor lands, and thus put the enterprise on a self-supporting basis as soon as possible.

2. Of the establishment of state forests hardly anything further need be said. If done honestly and liberally, so that the usual penny-wise, pound-foolish policy of our States does not spoil the enterprise, there is no reason why every forest State should not own and manage forests. If New Hampshire and the other New England States will only use their power of eminent domain, buy what mountain forests are needed to secure the beauty of that region, to control its waters and its industries, bond the States and secure the bonds by a mortgage on the woods, there should be no difficulty in making the forests pay the interest and, in a reasonable time, also the capital. If Michigan had kept its cut-over lands it would have had a good paying property to-day. If the Southern States will take over all their cheap cut-over lands, they will soon develop large properties which will be a blessing to future generations and prevent millions of acres of waste.

In discussing this matter much has been said in Michigan of having a certain part of every township in forests. It is a part of the scheme of leaving all forests in connection with farms, and thus making the farmer supply both wood and bread. But while it is highly desirable that the farm wood lot be preserved, that farm forestry be encouraged by every reasonable means, this plan will not suffice. There are whole counties in States like Wisconsin or Virginia that are practically all good land. In such counties the farmer will never be willing to devote more than from 3 to 5 per cent to forest, an amount entirely inadequate to supply even the farmer himself. On the other hand, there are in these same States entire counties where 85 or 90 per cent of the land is poor and not well suited to agriculture. Here the matter of forestry is foremost and becomes one of large holdings. If these holdings are in private hands it becomes either a matter of mischievous monopoly or else (what we now have) one of forest devastation and waste land, with constant conflict between the State trying to preserve and regulate and the owner trying to use up for his own present gain, regardless of waste. Under these conditions Europe has long since found out that it is only the State which will manage the forest well, and at the same time manage it for the good of the people.

State forests occupying all of the rougher and poorer lands should be the central figure of all state action in our country. What these forests can and should do financially has been mentioned and is discussed more fully elsewhere in this report.

3. The State should provide forest protection. In wrestling with this phase of state action the efforts have varied, but two distinct lines could always be recognized: The older measures, and those still most favored by the large majority of state legislatures, placed the burden on the town or locality where the property and the danger lie. More recent attempts, on the plea and assumption of inefficiency of the local government, have asked the State itself to undertake the protection by a properly organized state patrol. In the States where most legislation has been accomplished the discussion has resulted in a compromise, a state official, fire warden, or state forester, with one or more deputies forming the directive or administrative part, and a set of local fire wardens, either existing political officers, such as town supervisors, or else specially appointed fire wardens, forming the field service. In all cases these men are paid; the expense is usually divided between State and town. The wardens are clothed with power to call out the citizens, and the latter, and these only, are compelled to respond or be punished.

The older efforts, the placing of the burden entirely on the local people, evidently assumed that if the town gets nearly all of the taxes it should also do the bulk of the work. If the local people have to put out the fires, they will be diligent in preventing them, which is after all the main object to be accomplished.

Those arguing for state patrol maintain that the town is poor, and the burden too great for the few settlers, and that at any rate the town has proved entirely inefficient, so that if forests are to be protected the State must do it.

The use of the county authority has never entered the discussion, though in reality it may be assumed that the sheriff's office should furnish protection whenever the town authorities are unable to do so.

As stated before, in central Europe protection is furnished by the people of the locality fighting the fires, and patrol or prevention is secured through the foresters (on larger tracts), the local police, and the state police or gendarmes. But the chief feature here is that all must do their duty.

The writer himself has long favored a proper, paid state patrol, coupled with a form of special taxation which should place the financial burden on the owner of the lands to be protected. In providing state action the fact that prevention rather than fire fighting is the end desired should be kept in mind.

There are three distinct forms of state action that are to-day called for in forest protection:

(*a*) County and town should be held responsible for damages wherever it can be shown that a satisfactory, reasonable effort was not made by the town and county to protect the property against fires and incendiaries. When Allegheny County (Pittsburg) failed to make reasonable effort to protect the railway properties in 1877, the county was held responsible. This principle is just; without it government has no meaning. And this principle should be applied in case of forest fires. As stated above, our older laws, which simply demanded that the town fight the fires, were evidently based in part upon this principle.

If a certain county in Michigan had been held responsible for the fires of this year, the people would have prevented 75 per cent of all fires by prompt action; a number of irresponsibles would have been arrested and held until rain put an end to the danger; a number of others would have been brought into court and convicted; men would not have stood around with their guns on their shoulders merely inquiring whether the fire was coming their way instead of rendering the assistance which the law demands of them; nor would they protest against laws forbidding smoking in the woods, against the camper, hunter, and trespass during dangerous seasons, etc. This same responsibility would prevent the splitting of towns and counties. As it is, half our towns and counties were created to furnish jobs for local politicians who could no longer play boss of the larger town or county.

(*b*) Provide the machinery for the enforcement of law, the prevention and fighting of fires. Here the old original system as provided in Michigan would serve, provided it were made responsible and amplified. This could then well take on the following form: The citizens compelled to prevent and fight fires, as now, but ordinarily without pay from the State; the town officials compelled, on severe penalty, to do all in their power to prevent fires and to call out the citizens as soon as they learn of fires; the sheriff and his men to be fire wardens, compelled, on penalty, to arrest and bring to court any town official neglecting his duty as fire warden, and themselves compelled to call out men and act as fire wardens in the suppression of fires.

This system could and should be reinforced in every State by a body of state police to be distributed (say, one to each county) in all counties where 50 per cent or more of the area of the county is not occupied by farm settlers; these state policemen to act as regular police, patrol the district, enforce law in general, protect rural property, act as trespass agents for the state property, and also as game wardens if desired; to see that the county and town officials do their duty, and to have power to act as fire wardens, and in all greater emergencies to spend state funds for extra help used in such cases.

(*c*) Amplification of the forest-fire laws to regulate the following points: The right to go on other people's and state lands; the use of fire in clearing, in back firing, camp fires, etc., during certain seasons; smoking, the use of match and torch and firearm in and near forests during the dry parts of each year; the rights of men of bad record in and about forests; to make it prima facie evidence of guilt if a man is found near a forest fire where he has no business; to make it possible to prosecute officers and evildoers in a court sufficiently remote to insure impartial trial; to compel owners of woods to expend money in cleaning up their slash or guarding their forests in danger seasons; to give the right of arrest more liberally; to pay part or all of the fine to the informant. These provisions may seem harsh at present, but if enacted they would be taken as a matter of course within five years.

(*d*) The matter of forest taxation presents several difficulties. Usually the forest lands, and especially the large holdings of the lumbermen, were acquired not with a view to hold them and to convert them into regular forest properties, but merely as so much merchantable timber or material to be cut and sold as soon as possible or as fast as the market would take it. Since these formed the majority of cases, it was rather natural that the assessment should be made on the basis of what the material was worth or what the man paid for it. Then, again, the people argued: "This property was almost given away by the Government and has cost these men far less than it is worth, and as soon as they can they remove this wealth of timber and leave us the bare land." For these reasons it seemed even quite fair that the tax-gatherer should take rather a liberal slice, with the excuse that the money would serve to build roads and make other needed improvements.

But to-day the case is different. We are now eager to preserve these woods and to make the supply last as long as it will. And the owners of many of these forests are ready to-day to hold them and to handle them as regular forest properties. In addition, there comes the matter of reforestation of vast areas of land unfit for other uses, where there is no forest and where the case is entirely as on the farm; the trees will form a planted crop, due to the efforts of the owner. To complicate matters still more, we have certain intermediate cases where the owner is undecided, and asserts that he wants to hold part of his forest, but is not ready to say what part or for what period.

Generally it is conceded that the taxes should be so modified as to encourage both the holding of forest and forest planting, and these enterprises should not be discouraged. Various remedies have been suggested:

The special tax; merely a flat rate per acre of all forest land with the proviso that these taxes be used for specific purposes. This method is simple and feasible in every way.

Harvest tax; in this case a forest goes untaxed until the timber is cut, when a certain percentage of the sale value is paid as tax. This, more seemingly than in fact, has the disadvantage of leaving the local people without taxes for a number of years. In reality there would be a lot of timber cut in such a town every year, maybe by different owners, and thus there would be a steady though somewhat irregular revenue. This method would put a premium on holding forest and thus do some good; it is perfectly simple in execution, and therefore possible.

Combination harvest and land tax; here the land is taxed right along every year at its ordinary cash value, but the timber remains untaxed until cut, when a certain percentage of the stumpage value of the cut timber is paid as tax. This method has the advantage of furnishing a regular income, at least from the land.

Simple land tax to be applicable only to real forest properties and cases of reforestation; under this system the owner declares a certain area of forests or cut-over lands, wood lots, etc., to be forest property. He signs a contract with the State which gives the State a certain lien on the property; that it can dictate that the land may not be cleared and that the forest may not be devastated. This method is the simplest of all, applies to all woods alike, would work no hardship to anyone, would preserve the forest, furnish a regular tax income, and still enable the holding of woods and the reforestation of denuded lands.

In this case all timber not registered would continue to be treated in the ordinary way and might be taxed on the harvest-tax plan. It might be argued that this would leave too much property untaxed, etc. The fact is that the State of Michigan, for instance, could better afford to do without the tax from all its woods, making perhaps 2 to 3 per cent of all taxes, than continue to prevent by law so necessary an industry as forestry and the preservation of the forests now in existence.

An income tax or tax based on the net income of a forest property; here again a parcel or set of parcels of land would be declared forest property, the owner entering into an agreement with the State, and the assessment would be based on the net income (usually the average for, say, five years), at a certain percentage. This is thoroughly scientific and just and might be applied to any forest property, but in our conditions would often be difficult to use, since a regular yearly income from such a property is as yet the exception.

It is evident that this matter can be adjusted in various ways, and all that is really necessary is that there be a good will and that petty politics be left out of consideration.

All but the first of the above methods deal in reality only with the assessment and still leave the most mischievous matter, the tax rate, uncured. That this should be regulated, that every State should by law set a maximum at which any property may be taxed, should be evident. The only question is: What shall be the maximum? The average rate of taxation in Michigan is about from 1.5 to 1.7 per cent. For rural property in the well-farmed counties it is nearer 1.1 per cent, and certainly it should not be allowed to go higher in the poorly settled districts and on poor lands than in the good districts. The writer believes that $12 per $1,000 should be the maximum for all rural property. That the State has a right to do this, there can be little doubt. If not, it should have the right.

(*e*) The enforcement of right treatment of the forest by the owner is a matter of long standing abroad, and yet it has hardly been suggested in this country. The matter is quite plain, a simple law forbidding clearing without state permit and forbidding forest devastation under penalty will do the work. At first this will be quite crude, it will vary from place to place according to the notion of the officials, but in time it will work out to the good of the forest and of the people. If this form of action were properly extended, all forest taxation could at once be placed on a single land tax or on a net income basis.

(*f*) The laws encouraging and promoting forestry among the people may well be adopted more generally by all States. This line of action has met with favor from the first and no doubt will continue without much agitation. Work in school, the distribution of literature, free advice and free lectures by competent, trained men, the free distribution of plant material, the establishment of sample nurseries and plantations as object lessons throughout the State, the care of street and highway trees, will help to develop an understanding and love of the tree and the forest, and thus will repay a hundredfold in a better, more beautiful home for the generations yet to come.

PAST AND PRESENT PRICES OF FOREST PRODUCTS.

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The industrial development of the country necessarily results in marked changes in many directions. One of the favorite topics of discussion of late has been the alleged increase in the cost of living resulting from the increased cost of commodities in common use. There has been a large increase in the prices of many things, but, on the other hand, there has been a decrease in others. The result in any given case depends upon the character of the commodity. If it be one, the raw material of which is increasing in amount with the development of the country or which is in such abundant supply that exhaustion is not feared, invention resulting in decreased cost of manufacture usually makes a reduction in the selling price. This has been the case with iron and steel, which are much lower in price to-day than fifty years ago. If, on the other hand, however, it be one, the raw material of which is decreasing in amount with the development of the country and the resources of which are limited, the price must continue to advance. Such has been the case with the forest products of this nation, the prices of which have increased greatly, especially during the past two decades. This increase, however, has not been gradual. On the contrary, the prices have fluctuated from time to time, depending on the prosperity or "panicky" condition of the country. On the whole, however, the general tendency has been upward. The reasons for this are manifold, but principally the increased price may be traced to an ever-increasing demand, coupled with the realization on the part of the American people that the raw material required for these products is not inexhaustible, a condition brought about largely by the wonderful growth and prosperity of the nation. So great has been the demand that even with the increased facilities for the manufacture and transportation of the finished product and the enormous substitution of iron, brick, concrete, etc., for wood, prices have steadily advanced and our per capita consumption of lumber has increased from 215 feet in 1850 to the enormous consumption of 480 feet in 1907.

The cost of labor and of supplies of every description has during the past decade increased greatly, yet there seems to be an impression that the lumber industry should absorb all these increased items of cost and charge no more for its product.

On the other hand, the increased facilities for the manufacture of the finished product have tended somewhat to equalize this increased cost of labor and supplies, but have only succeeded in a very small proportion and not nearly to the extent that is generally supposed. There is an opportunity in this connection to present some figures as to the actual increase in lumber prices and in value of stumpage, which enter so largely into the cost, that ought to be convincing to the most obtuse. To be sure, stumpage is only one item of many that enters into the cost of producing lumber, but it is one which can not be ignored and which is the real keynote to the situation.

From recent reports of the Forest Service and the Bureau of the Census the following table has been compiled:

Average value of stumpage and of lumber at the mill.

	Stumpage.		Per cent increase.	Lumber.		Per cent increase.
	1900.	1907.		1900.	1907.	
White pine	$3.66	$8.09	121.0	$12.66	$19.41	53
Ash	3.03	7.58	150.0	15.84	25.01	58
Basswood	1.50	6.79	352.6	12.84	20.03	51
Hickory	(a)	6.69	....	18.78	29.50	57
Oak	[b] 3.18	6.52	105.0	13.78	21.23	54
Spruce	2.26	[c] 5.49	142.8	11.27	17.26	53
Chestnut	2.71	4.97	83.0	13.37	17.04	27
Elm	3.30	4.94	49.6	11.47	18.45	61
Poplar	2.81	4.64	65.0	14.03	24.91	78
Cedar	1.32	4.63	250.0	10.91	19.14	75
Hemlock	2.56	[d] 4.51	76.0	9.98	15.53	56
Birch	(a)	4.40	....	12.50	17.37	39
Cypress	1.58	4.37	176.0	13.32	22.12	66
Cottonwood	1.45	3.97	173.0	10.37	18.42	77
Beech	....	3.56	....	(a)	14.30	....
Yellow pine	1.12	3.16	182.0	8.48	14.02	65
Maple	2.66	2.50	[e] 6.0	11.83	16.84	42
Red gum	1.68	2.46	46.0	9.63	14.10	46
Redwood	1.06	2.35	121.0	10.12	17.70	75
Western pine	(a)	1.66	....	9.70	15.67	62
Douglas fir	.77	1.44	87.0	8.67	14.12	63
Tupelo	(a)	1.27	....	(a)	14.48	....
Average, all kinds	....	....	....	11.08	16.58	49

[a] Not separately reported.
[b] White oak only.
[c] Eastern spruce only.
[d] Eastern hemlock only.
[e] Decrease.

First are given stumpage values of 1900 and 1907. Those in the latter year are the result of special inquiries made by the Forest Service, which secured more than 1,500 reports, widely scattered and obtained from authoritative sources. The lumber prices given are at the mills, and are derived from the total product for the respective years and the aggregate value.

The wood first upon the list is white pine. Its stumpage value increased 121 per cent, while the mill values increased but 53 per cent. More important, because of its larger product, is yellow pine. The increase in the stumpage value was 182 per cent and in lumber value only 65 per cent. Among the soft woods, the next most important item is Douglas fir; there the contrast is not so great, for while the stumpage value increased 87 per cent, the lumber value increased 63 per cent. Cypress shows a stumpage increase of 176 per cent and a lumber increase of only 66 per cent. Oak stumpage increased in value 105 per cent and oak lumber only 54 per cent. Cedar stumpage value increased 250 per cent and lumber but 75 per cent. It is unnecessary to go through the list, but it may be noted that among all soft woods the lowest increase in stumpage is only about equal to the highest increase in mill values.

The hard woods do not show such great discrepancies, but even there the contrast is marked in some cases, especially in oak and cottonwood. In some instances the lumber increase was greater than that of stumpage. The figures for maple, on first thought, might be questioned, as it is difficult to understand why there should have been any decrease in the value of stumpage as shown by the comparison. This may partly be explained, however, by the fact that maple is a wood which has a number of very strong competitors in all the uses to which it is put. This has to a large extent kept down its demand; and the building of railroads into hitherto inaccessible tracts of hard woods in the past few years has opened up a great many maple tracts and consequently thrown on the market large amounts of both lumber and stumpage, possibly even more than the demand warranted. However, the woods of largest production all show that the item of stumpage cost has increased in vastly greater ratio than the mill prices.

And why this increase in the cost of stumpage? During the past decade a most potent influence has been at work to cause this, viz, the awakening of the American people to the realization that their forest resources are not inexhaustible. The realization of an impending crisis has, during the past decade, made itself markedly felt in the lumber industry, and principally, of course, in the increase in the cost of stumpage. This is graphically shown in Table I. The increase advanced slowly for several decades but increased by leaps and bounds during the past few years. The only break noted in the continued rise in price since 1866 is from 1892 to 1896, when the decrease in price reflects the business depression which swept over the country at that time. Had not this occurred it is safe to presume that the advance would have been gradual from $7.00 in 1892 to $9.00 in 1898.

In case of wood we must not overlook that lumber prices do not really represent wood prices, for the price of a manufactured product like lumber, at places of consumption, includes the cost of manufacture, the cost of transportation, of brokerage, etc., and finally is influenced by the competition of manufacturers; changes in all of which conditions are reflected in the price. Thus it has happened that, owing to improvements in machinery, cheapening of transportation, change in methods of trade, and active competition, lumber prices have for quite long periods remained stationary, while stumpage prices, that is, wood prices pure and simple, have risen. For instance, the stumpage of white pine in Michigan rose during the twenty years from 1866 to 1887 from $1 per thousand feet, by constant steps, without a break, to between $4.50 and $6.50, while the white-pine lumber log run fluctuated during the whole period only between $11.50 at the beginning and $13 at the end, being never higher than $14 and, for five years of that period, sinking as low as $9 and $10.[a]

From this example alone we see that lumber prices do not move proportionately to wood prices and can not, by themselves, be used for the discussion of the latter. With regard to the variation of quality, we must keep in mind that wood is a material which serves two very different classes of purposes; namely, that in which the

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[a] Report of Saginaw Board of Trade.

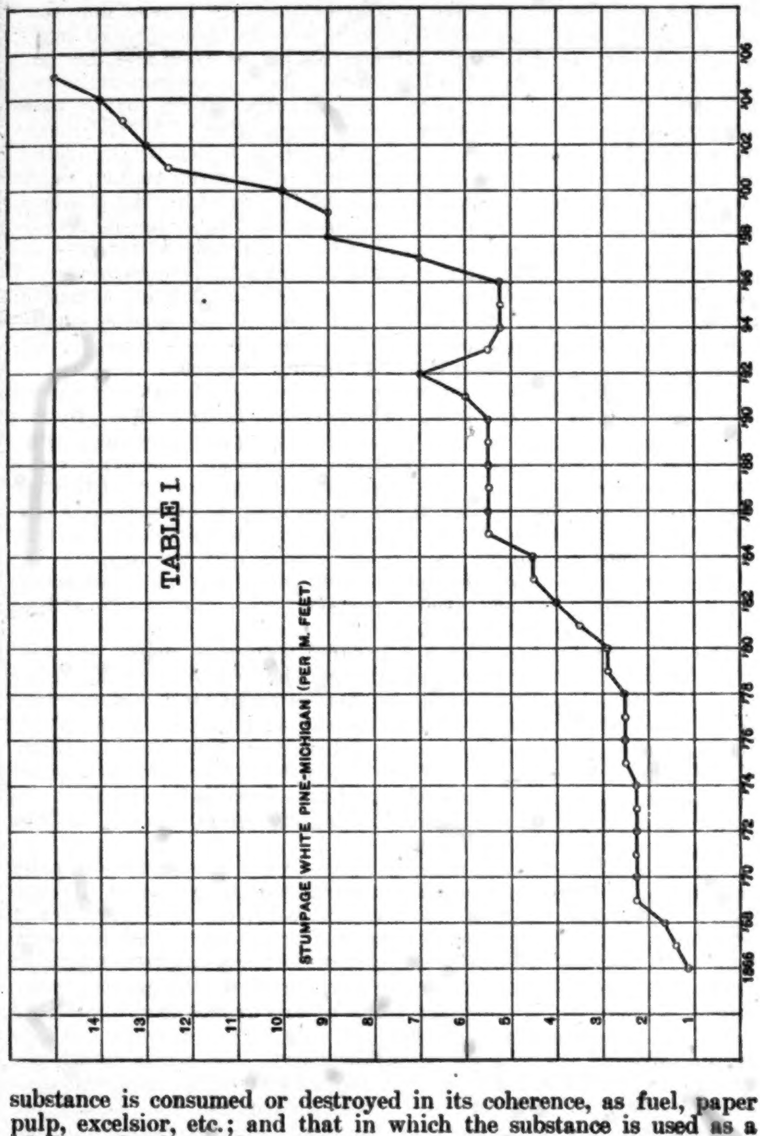


TABLE I

STUMPAGE WHITE PINE-MICHIGAN (PER M. FEET)

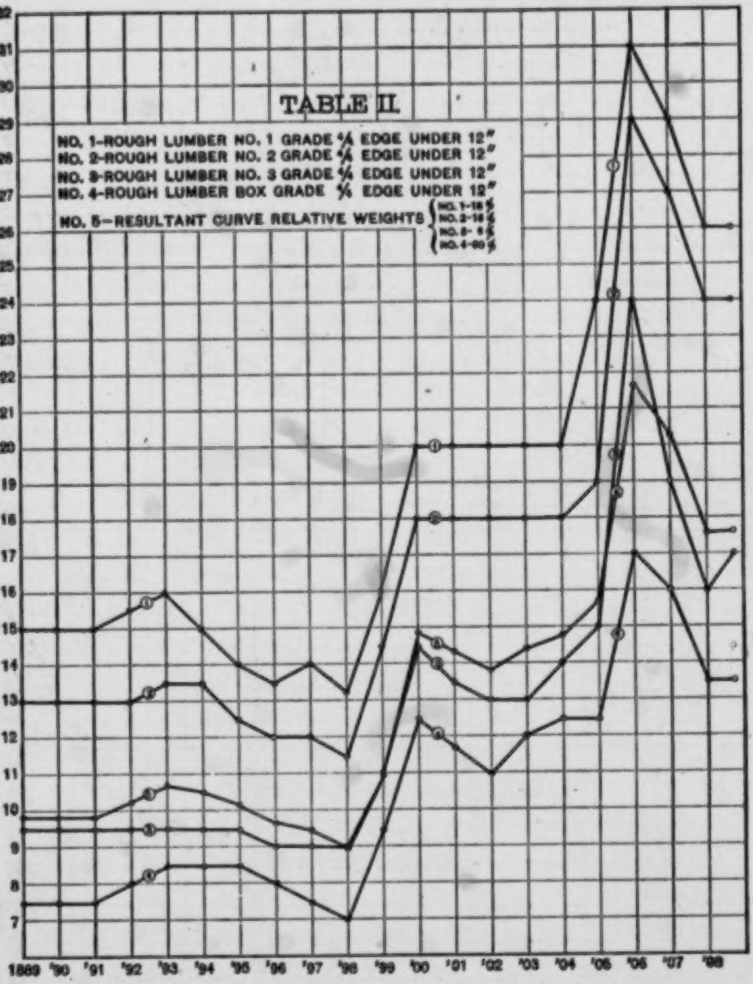
substance is consumed or destroyed in its coherence, as fuel, paper pulp, excelsior, etc.; and that in which the substance is used as a whole, as lumber and construction.

In the first class of uses quality of material, and especially the size, although a requisite, may vary within wide limits; for the second class of uses, more definite qualities, and especially certain size, which in wood is itself a quality, are requisite. Size is a function of age, and the other qualities which make satisfactory logs for lumber manufacture, namely, clean materials, free from loose knots and small taper, are also in part results of age. Hence this use of wood and this portion of the forest growth, the log timber, is the more important one, and here the time element enters prominently, which makes wood from the economic point of view a material peculiar to itself, different from any other product, owing to the long time which its production requires. As a consequence, we may find for a given region, as for instance in Massachusetts, that the price of fuel wood has not changed, or, if anything, has decreased, while that of saw timber has increased; the reason being that the local supply of material only fit for firewood has become relatively greater since the cut-over lands were robbed of the old timber and young or inferior growth has become a general feature. Similarly, we will find the prices of the best-quality lumber varying in a different manner from those for inferior grades, the latter as a rule being in oversupply and sagging in price.

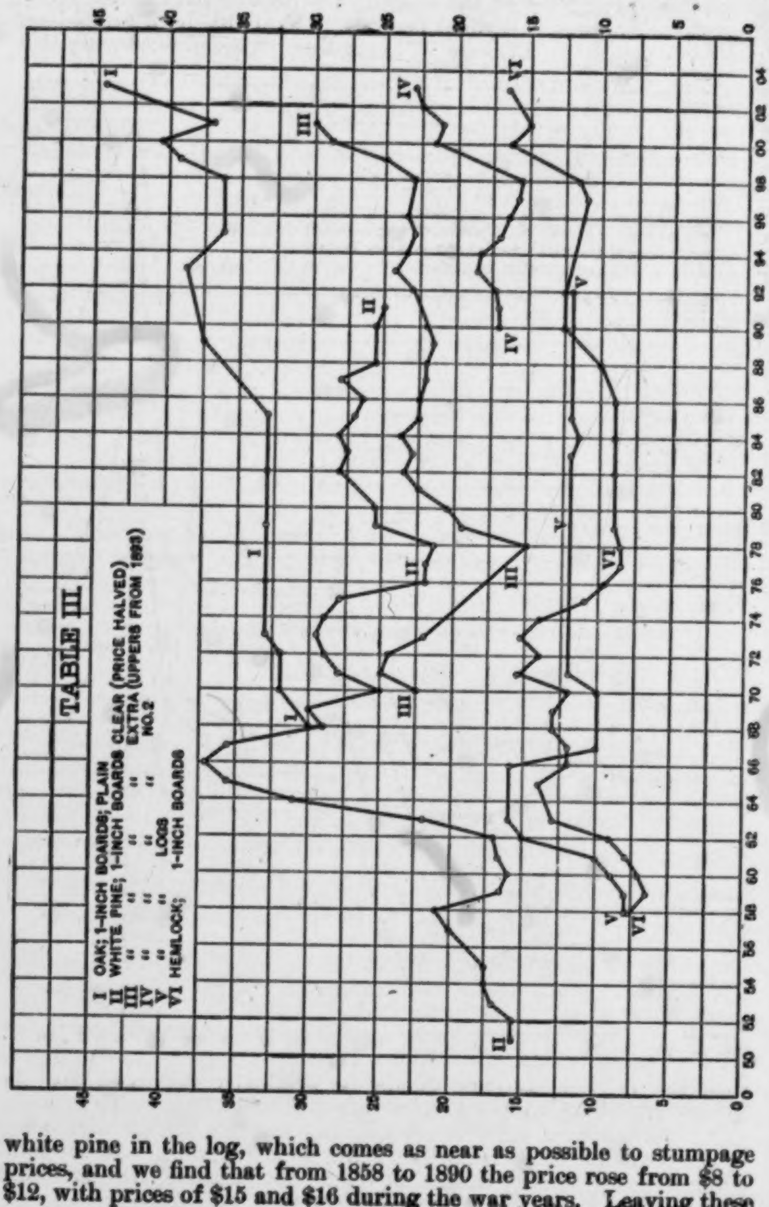
Again, the importance and hence the quantity of consumption of different kinds of wood varies. The soft woods, and especially the conifers, answering the greatest variety of purposes, are the largest and most important requirement of our civilization, the hard woods being less prominent in our consumption in the proportion of three to one. Hence, although prices of the latter may be higher, their economic importance is, generally speaking, inferior to that of conifers, especially when we survey the world's sources of wood supply. We must not class the large amount of hard, beautiful, tropical woods, which are mainly for ornamental purposes, with our structural timber supply of the Temperate Zone.

The price of lumber does not parallel stumpage prices, the tendency being to more uniform and relatively lower lumber prices, owing to continental competition in the market, as well as to the cheapening of processes of manufacture, of trade, and of transportation. There are also other factors which assist in bringing about this condition, viz., the increased utilization of top logs and the decrease in diameter of cutting, as well as the use of logs formerly culled and left in the woods, thus throwing on the market a very great amount of low-grade, low-priced lumber.

Moreover, the different grades of lumber vary considerably in price and fluctuate differently, so that it is difficult to get at an average price. This is very aptly shown in Table II, where is graphically presented the rise in price of four grades of North Carolina pine from 1889 to 1908. It will be noted that the curves representing each of the four grades follow each other very closely in the general trend, though, as may be expected, the prices of low grades tend to advance slowly and high grades very rapidly, due to the growing scarcity of high-grade logs. In the resultant curve (No. 5) is shown the average price of the four grades, the grades being given the relative weights of 18 per cent for No. 1 grade, 16 per cent for No. 2, 6 per cent for No. 3, and 60 per cent for box. This proportion for all the years, however, is not a correct one, but will serve in giving a general indication of the selling price for the total product. To be more correct, a higher relative weight should be given the higher grades in the first decade and a correspondingly lower weight to the low grades, since at this time there was a greater percentage of high-grade logs coming out of the woods. During the past decade, however, there has been a gradual decrease in available high-grade logs, and consequently an increase in low grade. Therefore, during this time the relative weights should be gradually decreased for the higher grades of lumber and increased for the lower. This would make the resultant curve higher during the first decade and lower in the second, thus showing that while the average price of the total product has gradually increased, it has not been so great as would appear from the resultant curve presented.



Nevertheless, when prices of lumber of all grades rise steadily the ultimate cause may be sought in the increased cost of raw material. In Table III we have a short but significant series of prices for



white pine in the log, which comes as near as possible to stumpage prices, and we find that from 1858 to 1890 the price rose from $8 to $12, with prices of $15 and $16 during the war years. Leaving these latter excessive rates out of consideration, the rise during the thirty-two years appears to be at a rate of not much more than one-half of 1 per cent. Hemlock logs rose during the same period from $6 to $8, or at the rate of about 1 per cent; white-pine lumber, 1 inch clear, on the other hand, rose from about $30 in 1840 to $50 in 1891,

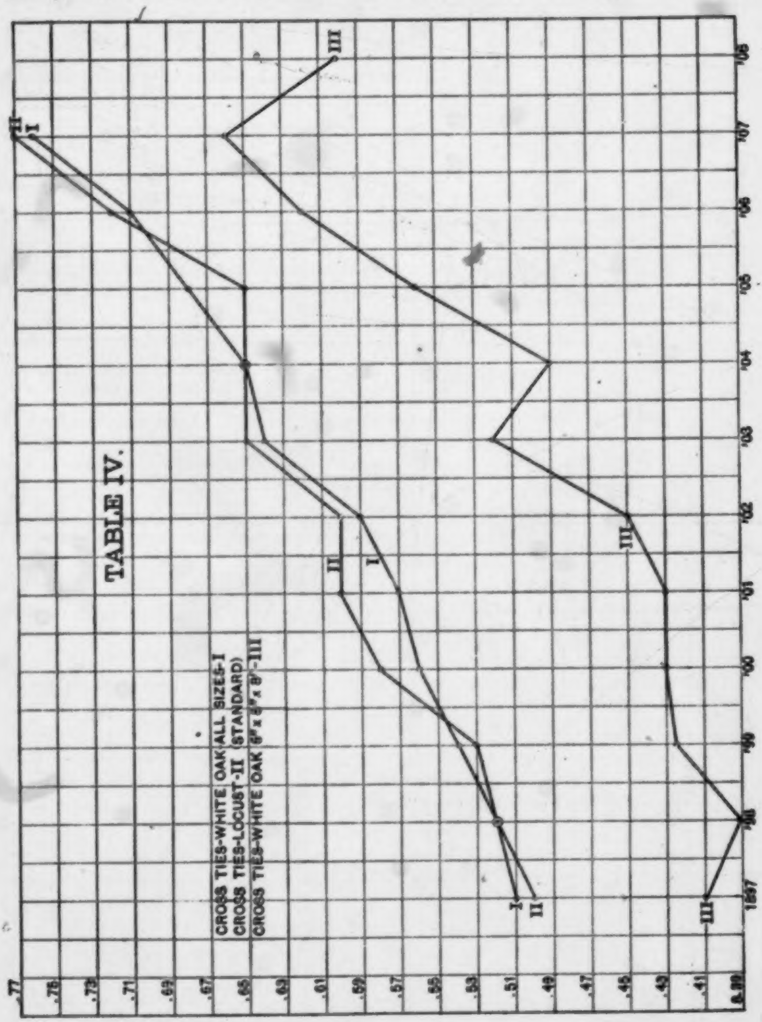
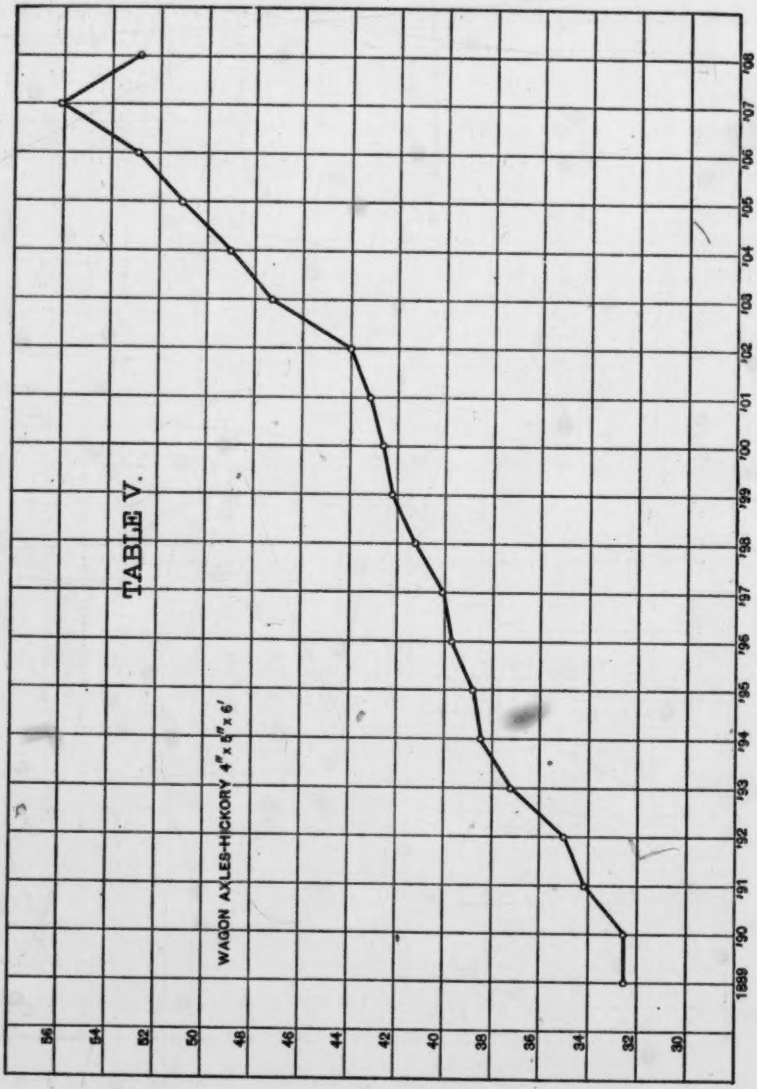
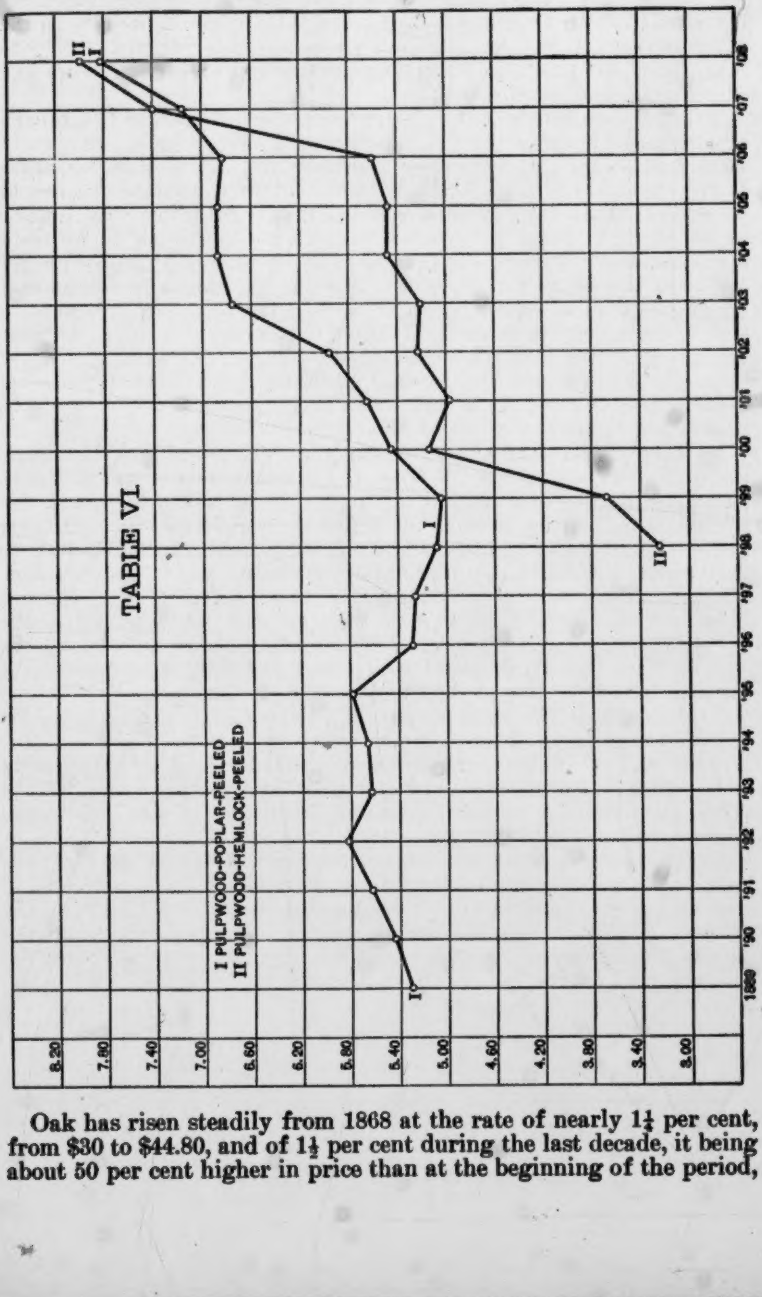


TABLE IV.

or at the rate of 1 per cent, but from 1890 to 1900 the rate of rise in uppers was from $44 to $57.50, or 2¼ per cent, while from 1900 to 1903 a phenomenal rise to $80, or at the rate of over 6 per cent, has taken place. At the same time the price of number two, 1-inch boards, rose from $16.80 to $24, or at the rate of 2½ per cent. The change in quality appears in the two converging curves of the earlier period, the quality uppers combining the two after 1890. It is now well known that the end of white pine as a great lumber staple is near



at hand, and hence this sudden rise, but the price of other woods also has risen, although not quite so rapidly. For hemlock inch boards the rate during the last twenty-five years has been 2¼ per cent, and during the last ten years 3½ per cent, namely, from $12 to $16.80, and if we go back forty-five years and leave out of consideration the influence of the war years, the increase has been at the rate of 1¾ per cent per year.



Oak has risen steadily from 1868 at the rate of nearly 1¼ per cent, from $30 to $44.80, and of 1½ per cent during the last decade, it being about 50 per cent higher in price than at the beginning of the period, thirty-five years ago. Yellow pine, of which large supplies are still in sight, has shown little change, having in the last fourteen years hardly moved upward, although fluctuating $4 and more within that period. This evenness of price is due probably to the rapidly increasing competition among mill men in the southern section of the country, for it is well known that stumpage prices have, especially in the last ten years, grown at an almost incredible rate, stumpage of pine being held now at from $2 to $3 per thousand which ten years ago was bought for 50 cents to $1.

We may then conclude that as far as lumber prices reflect stumpage prices, these, even in the United States, in spite of the apparently large home supplies, have risen suddenly and are now rising much faster than in the period before 1890. In fact, we have reason to believe that stumpage prices are rising relatively faster than lumber prices, for the latter have a tendency to be depressed, as we have stated before, by trade competition and by new supplies becoming available and being thrown on the market, the necessities of the case forcing mill men, especially in times of industrial retrogression, to accept inadequate pay, while timber-land owners can afford to wait for improvement in market conditions.

In addition to prices of lumber and stumpage, there is also presented with this report a series of curves showing the increase in price for a number of years of other forest products.

In Table IV is shown the increase in cost of cross-ties. It will be noted that the curves for all sizes of white-oak and standard locust ties show no decrease during the past decade, while the curve for white-oak 6-inch by 8-inch by 8-foot ties reflect both the overproduction of material in 1903 and the business depression of 1907–8. The reason for this latter reflection is probably due to the fact that the 6-inch by 8-inch by 8-foot oak ties constitute the bulk of the ties used and therefore react closely with general business, while the curves for locust and all sizes of white-oak ties were held up by the cost of higher-grade material which does not readily respond to a general depression due to the decrease in their demand.

In Table V is shown the increase in the cost of hickory wagon axles. Being made from a wood which is highly prized for this purpose and which is constantly decreasing in supply and increasing in demand, no overproduction has resulted and the price has steadily increased until the general financial depression of the past year, when it fell off slightly.

In Table VI is presented the prices of hemlock and poplar pulp wood. The same general fluctuations are noted in these curves as in the preceding ones, with the exception that in the past few years the scarcity of future supplies has made itself markedly felt and the price has continued to advance most rapidly, not even reflecting the last financial depression of 1907–8.

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WITH ACCOMPANYING PAPERS

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ACCOMPANYING PAPERS

LANDS, MINERALS, AND NATIONAL VITALITY

CROP YIELD PER ACRE.

By V. H. Olmsted,

Chief of Bureau of Statistics, United States Department of Agriculture.

In compliance with the request of the commission for information regarding the average yield per acre, by decades, of certain leading representative agricultural crops of the United States, to be used in answering one of the inquiries propounded by the executive committee of the National Conservation Commission, I hand you herewith three statements, marked "A," " B," and " C," respectively.

The statement marked "A" shows the average yield per acre for the decades 1867–1876, 1877–1886, 1887–1896, and 1897–1906, of nine of the principal crops, to wit, corn, wheat, oats, barley, rye, hay, buckwheat, potatoes, and cotton, for each State and Territory, with the total average yield for the same decades for the United States of each crop.

The statement marked " B " shows the average yield per acre in the forty years 1867–1906, and the average yield in each decade for the same crops covered by the statement marked "A," in the United States as a whole.

The statement marked " C " compares, in percentages, the average yield per acre of the crops in question in each decade with the average yield per acre for the entire forty years, the yield for the whole period being represented by 100.

The inquiry to which these figures are given in reply, taken in connection with its subinquiries, is apparently based on the presumption that there has been, and is constantly going on, a diminution in the average productivity of the soil.

A perusal of the figures submitted shows such presumption to be erroneous. A brief glance at the statement marked " C " will convince one of this fact, as it stands out with great plainness that during the decade ending with 1906 there was a substantial increase in productivity as compared with the entire forty-year period. This is not true of a single crop only, but of every crop covered by the statement, and were it possible to give exhaustive figures regarding many other crops the same results would undoubtedly be shown.

That there should be an increase instead of a decrease in the soil productivity might be expected when the work which has been carried on by the Department of Agriculture is taken into consideration, particularly during the last dozen years. It would be strange, indeed, if all the work of this great department should result in no advantage to the agricultural interests of the country.

A brief mention of some of the lines along which the betterment of agricultural industry has been accomplished by the Department of Agriculture may not be out of place in this connection:

The Bureau of Plant Industry, whose ramifications extend to every section of the country, is constantly teaching the farmers how to improve their crops by breeding and selection; how to put into operation the best methods of farm practice; and how to prevent diseases in plants. It is constantly securing and distributing new and improved varieties of seeds and plants; studies and disseminates information as to their adaptability to the various sections of the United States, and is continuously carrying on the enormous work which must, in the very nature of things, result in vast improvement in agricultural conditions.

The Bureau of Soils investigates soils in their relation to crops; their adaptation to crops; their proper utilization and management; and information is disseminated in relation thereto, to which all farmers have access.

The Office of Experiment Stations represents the department in its relations to the agricultural colleges and experiment stations scattered throughout the length and breadth of the United States. In these experiment stations ocular demonstrations are given of the best methods of cultivation and of the best varieties for the cultivator.

The Bureau of Entomology obtains and disseminates information in regard to injurious insects affecting field crops, fruits, truck crops, forest, and forest products, etc., and gives instructions as to the best methods for their suppression or the prevention of their ravages.

The Bureau of Biological Survey investigates the economic relations of birds and mammals which are beneficial to agriculture, and also of those which are destructive.

The Bureau of Chemistry makes such investigations and analyses as pertain in general to the interests of agriculture, dealing with fertilizers and agricultural products.

The Weather Bureau gives timely warning by the display of weather and flood signals, and issues storm warnings for the benefit of agriculture, which information enables farmers to adopt measures for the protection of their growing crops or those already harvested.

The beneficial effects of the work of these bureaus, and of the Department of Agriculture generally, are clearly shown by the figures covering the last decade, during which their operations have been actively and widely extended.

The agricultural resources of the country have been, and are constantly being, conserved by the Department of Agriculture; and it is impossible to estimate in terms of dollars and cents the enormous benefit that has accrued to the farmers of the United States through the operations of this department. The amount of money which has been expended by it under congressional appropriations is a mere bagatelle when compared with the amount gained by the people through its operations.

A.

Yield per acre.

(Ten-year average.)

States and Territories.	Corn (bushels).				Wheat (bushels).				Oats (bushels).			
	1867-1876.	1877-1886.	1887-1896.	1897-1906.	1867-1876.	1877-1886.	1887-1896.	1897-1906.	1867-1876.	1877-1886.	1887-1896.	1897-1906.
Maine	29.1	33.8	34.9	35.1	13.2	13.9	16.6	22.4	25.6	27.5	33.1	36.4
New Hampshire	36.5	34.8	35.2	33.6	15.1	14.6	16.4	[d]17.1	32.9	34.9	32.6	33.2
Vermont	36.6	34.7	36.3	34.5	16.4	17.2	19.3	21.0	34.6	34.6	34.2	30.9
Massachusetts	34.7	32.3	36.7	35.6	17.0	17.8	[e]14.8	......	30.6	31.0	31.5	32.9
Rhode Island	27.7	30.4	31.5	31.8	[e]16.8	[b]12.8	......	......	30.6	28.7	28.5	28.4
Connecticut	30.9	29.2	33.8	36.0	16.9	16.7	[e]16.1	[d]19.8	30.4	28.5	26.7	31.3
New York	31.9	30.5	31.3	30.4	14.1	15.6	15.4	17.9	31.8	30.5	26.7	31.4
New Jersey	35.8	31.9	31.5	34.6	14.6	13.5	13.4	16.4	27.5	29.1	26.7	26.3
Pennsylvania	35.2	31.9	31.6	34.5	13.5	13.4	13.7	16.2	30.2	30.2	28.0	29.5
Delaware	21.9	21.2	20.4	27.6	11.7	12.1	12.7	15.8	17.7	22.3	20.5	23.2
Maryland	24.6	25.2	24.6	32.3	10.9	12.8	13.8	15.8	19.4	20.7	20.2	23.9
Virginia	20.0	17.5	18.0	21.3	8.5	8.3	8.9	10.6	15.9	11.9	14.0	16.0
West Virginia	29.2	25.3	22.9	26.4	10.4	10.7	10.2	11.0	23.5	19.8	19.7	22.4
North Carolina	14.6	12.9	12.6	13.7	7.3	6.4	6.4	7.7	13.8	11.0	11.3	13.9
South Carolina	10.0	8.9	10.2	9.8	6.4	6.3	5.9	7.9	11.1	11.4	11.3	15.5
Georgia	11.8	10.3	11.2	10.6	7.1	6.8	6.5	8.1	12.1	10.9	11.9	14.0
Florida	10.6	9.6	10.1	9.4	[c]9.0	[b]4.8	......	......	13.0	11.1	11.4	12.4
Ohio	35.2	32.1	29.7	34.9	12.8	14.9	13.8	14.9	29.0	31.2	29.1	35.0
Indiana	31.7	30.4	29.2	34.5	11.5	14.3	13.3	13.4	24.5	27.5	26.2	30.9
Illinois	29.3	27.2	30.6	34.0	11.5	13.5	14.4	13.5	29.1	34.4	30.0	32.6
Michigan	31.9	31.8	27.6	32.0	13.2	16.5	14.5	13.8	31.8	32.9	28.9	32.8
Wisconsin	32.0	29.5	28.6	33.6	13.2	12.4	13.2	16.0	33.6	32.9	31.0	35.1
Minnesota	31.5	31.4	27.7	29.4	14.4	13.4	13.7	13.0	34.1	35.2	30.9	33.2
Iowa	34.2	31.4	31.5	32.5	11.6	10.8	13.3	14.1	34.6	33.9	30.8	31.6
Missouri	29.8	28.1	28.2	28.0	12.3	11.5	12.7	12.5	28.4	26.9	23.5	23.0
North Dakota	......	[e]25.2	[f]22.6	21.9	......	[e]14.1	[f]14.0	12.3	......	[c]33.7	[f]27.0	30.1
South Dakota			[f]18.3	26.6			[f]11.0	11.4			[f]23.4	31.3
Nebraska	32.5	35.2	26.2	27.7	13.4	11.8	11.1	16.2	32.7	30.9	23.2	29.0
Kansas	34.5	31.2	22.8	22.1	15.0	13.6	12.7	14.2	32.1	30.1	23.1	24.9
Kentucky	29.4	25.2	25.2	26.0	9.5	9.8	10.9	11.8	21.4	19.6	18.9	21.2
Tennessee	23.2	21.0	21.7	22.4	8.0	6.4	8.4	9.9	17.3	15.4	15.2	17.5
Alabama	14.4	12.3	12.8	13.0	7.7	6.4	7.0	9.4	13.3	12.1	12.3	14.4
Mississippi	16.1	14.0	14.8	15.2	9.5	5.8	7.4	9.6	15.6	12.3	12.6	15.8
Louisiana	18.3	16.2	16.0	16.8	[d]9.1	[b]3.4	......	......	[i]16.5	[i]13.3	13.5	16.8
Texas	23.6	18.9	18.3	19.0	12.9	10.5	10.5	12.2	27.1	26.7	23.1	29.1
Indian Territory	......	......	......	[f]27.2	......	......	......	[f]12.1	......	......	......	[f]31.7
Oklahoma	......	......	......	[h]23.5	......	......	[e]11.9	14.2	......	......	......	[f]30.6
Arkansas	25.7	21.0	18.5	18.8	10.5	7.0	8.6	9.4	22.5	18.7	17.7	19.5
Montana	......	[e]26.2	[f]26.4	22.0	......	[e]17.5	20.8	26.7	......	[c]35.7	33.2	41.2
Wyoming	......	......	[c]23.9	24.9	......	[e]17.4	[f]21.0	23.0	......	[c]30.0	[g]30.5	34.6
Colorado	......	[g]26.2	21.3	19.9	......	[g]19.2	19.0	24.6	......	[g]31.1	28.0	33.4
New Mexico	......	[e]20.4	20.3	24.5	......	[e]13.2	15.6	20.0	......	[e]21.8	26.7	28.5
Arizona	......	[e]21.3	[e]19.8	[f]23.5	......	[e]13.8	16.2	21.8	......	[e]25.0	......	[f]33.0
Utah	......	[e]22.7	20.4	24.5	......	[e]17.5	18.8	23.5	......	[e]26.0	29.5	37.1
Nevada	[g]30.9	[g]23.9	[e]27.8	......	[g]21.1	[g]17.3	19.2	26.0	[g]33.9	[g]31.1	[b]25.2	[f]36.6
Idaho	......	[e]22.3	[e]24.8	[f]27.8	......	[e]16.9	19.2	23.8	......	[c]33.0	32.5	39.2
Washington	......	[e]26.3	[g]19.0	21.1	......	[e]16.5	17.7	23.3	......	[c]37.7	35.8	44.1
Oregon	[h]29.5	26.0	23.8	24.3	[h]18.6	17.1	17.1	18.7	[h]35.4	30.4	27.1	28.2
California	[i]37.9	28.6	30.6	29.7	[i]14.6	12.9	12.7	11.6	[i]33.9	27.3	28.3	29.6
The Territories	[i]29.4	[c]29.4	......	......	[i]21.5	[e]15.4	......	......	[i]34.1	[c]29.1	......	......
United States	26.2	25.1	24.0	25.4	12.0	12.5	12.7	13.8	27.5	27.8	25.5	30.1

[a] 1 year.
[b] 2 years.
[c] 3 years.
[d] 4 years.
[e] 5 years.
[f] 6 years.
[g] 7 years.
[h] 8 years.
[i] 9 years.

Yield per acre—Continued.

States and Territories.	Barley (bushels).				Rye (bushels).				Hay (tons).			
	1867-1876	1877-1886	1887-1896	1897-1906	1867-1876	1877-1886	1887-1896	1897-1906	1867-1876.	1877-1886.	1887-1896.	1897-1906.
Maine	19.3	21.6	25.0	28.8	16.3	14.0	14.0	[d]15.9	0.88	0.97	0.97	1.06
New Hampshire	24.7	21.6	24.1	21.9	17.2	11.7	14.2	[d]16.9	1.00	.95	.98	1.08
Vermont	24.1	25.7	26.7	31.2	16.5	15.4	14.3	17.3	1.05	1.05	1.17	1.27
Massachusetts	23.0	23.0	23.7	[d]28.7	16.2	15.0	15.4	16.1	1.10	1.14	1.15	1.30
Rhode Island	22.2	[i]22.6	24.7	[d]23.2	16.0	12.6	[f]13.2	......	1.02	1.04	.96	1.05
Connecticut	22.8	[i]21.8	[f]22.2	......	14.3	14.2	14.0	17.7	1.19	1.08	1.02	1.12
New York	21.9	23.0	21.1	24.4	13.8	13.0	13.8	16.3	1.21	1.15	1.09	1.24
New Jersey	[h]23.5	[i]17.0	[d]21.2	......	13.7	11.6	12.6	16.1	1.26	1.14	1.18	1.29
Pennsylvania	21.4	21.9	19.6	21.6	13.7	11.7	13.1	16.3	1.19	1.20	1.15	1.30
Delaware	[h]19.8	......	[d]21.9	......	9.3	10.3	[f]8.2	[f]13.4	1.13	1.02	1.14	1.30
Maryland	[h]20.4	[e]25.8	[d]22.6	[f]25.8	12.1	11.3	11.2	14.8	1.11	1.09	1.13	1.22
Virginia	[h]16.3	[f]16.2	[f]18.4	[f]24.8	10.2	7.7	8.4	11.6	1.18	1.16	1.07	1.22
West Virginia	17.0	[i]16.5	[f]22.0	......	13.0	9.9	9.4	11.1	1.17	1.10	1.04	1.36
North Carolina	[h]16.0	[f]11.1	[e]18.5	......	9.0	6.6	6.7	9.0	1.29	1.25	1.29	1.54
South Carolina	[h]12.9	[e]14.2	[d]19.3	......	6.4	4.8	5.6	7.5	1.01	1.15	1.24	1.37
Georgia	[i]14.0	[g]14.2	[e]18.3	......	[i]7.4	[g]5.6	6.0	7.4	1.29	1.34	1.28	1.53
Florida	[c]14.2	......	[d]21.2	......	[d]9.6	[c]4.9	[d]13.6	......	[d]1.15	[c]1.06	[g]1.39	1.38
Ohio	22.8	23.4	24.0	27.6	12.8	13.2	14.0	17.1	1.19	1.24	1.17	1.35
Indiana	21.5	[i]23.3	20.8	25.5	14.0	12.4	13.8	14.5	1.29	1.32	1.17	1.36
Illinois	22.4	21.7	22.3	27.5	16.1	16.1	14.9	16.8	1.36	1.38	1.18	1.32
Michigan	21.6	24.3	21.5	24.8	15.4	12.9	13.1	15.0	1.22	1.27	1.15	1.34
Wisconsin	26.0	24.5	25.7	29.2	15.6	14.4	14.3	16.3	1.35	1.28	1.19	1.54
Minnesota	25.2	26.0	24.9	26.4	18.5	16.4	16.3	19.0	1.46	1.40	1.30	1.66
Iowa	23.0	22.5	23.0	25.8	17.9	[i]13.4	15.7	17.7	1.48	1.35	1.25	1.54
Missouri	22.0	[g]20.5	20.2	20.5	15.8	13.1	12.7	14.3	1.40	1.25	1.18	1.27
North Dakota	......	[e]22.8	[h]21.2	24.4	......	[e]16.2	[h]13.7	15.6	......	[e]1.32	[h]1.23	1.46
South Dakota			[h]18.6	25.0			[h]10.2	16.6			[h]1.09	1.36
Nebraska	26.5	20.1	19.5	24.9	18.6	[i]15.0	12.4	17.0	1.55	1.45	1.15	1.58
Kansas	24.0	19.0	16.9	21.5	18.8	16.5	10.6	14.3	1.46	1.40	1.16	1.43
Kentucky	20.4	22.7	23.0	22.3	11.2	10.2	10.9	13.2	1.25	1.24	1.19	1.36
Tennessee	19.0	[g]14.0	16.0	18.2	9.6	[i]7.2	7.6	11.3	1.31	1.26	1.23	1.50
Alabama	[e]12.6	[e]10.4	[d]20.2	......	[i]8.9	[g]5.7	7.9	10.0	1.25	1.31	1.48	1.74
Mississippi	[d]11.2	......	[d]20.4	......	[i]9.9	[e]6.9	[f]7.3	......	1.32	1.32	1.47	1.68
Louisiana	[e]18.2	......	[d]21.3	......	[e]11.2	[e]7.4	[e]9.9	......	[i]1.45	[f]1.15	1.57	1.99
Texas	25.7	[g]18.1	15.2	22.6	15.9	[i]11.8	8.9	12.7	1.40	1.26	1.22	1.61
Indian Territory	......	......	......	......	......	......	......	......	......	......	......	[f]1.41
Oklahoma	......	......	......	[f]28.5	......	......	......	[f]14.0	......	......	[a]1.32	[f]1.32
Arkansas	[d]15.0	......	[d]20.0	......	13.1	8.6	8.3	11.1	1.38	1.31	1.22	1.53
Montana	......	[e]28.5	27.5	30.0	......	......	......	[f]22.8	......	[e]1.09	1.16	1.69
Wyoming	......	......	......	[f]28.6	......	......	......	[f]20.2	......	[c]1.18	1.22	1.93
Colorado	......	[g]23.4	26.1	31.6	......	[g]18.5	16.2	17.2	......	[g]1.15	1.75	2.23
New Mexico	......	[e]19.5	22.0	27.0	......	......	......	......	......	[e]1.10	1.70	2.59
Arizona	......	[e]19.2	[i]22.6	[f]34.4	......	......	......	......	......	[e].98	1.70	3.00
Utah	......	[e]22.4	26.9	36.1	......	[e]11.0	14.5	16.7	......	[e]1.30	1.81	3.02
Nevada	[g]27.2	[g]21.8	[i]27.5	[f]34.8	[g]25.0	......	[d]12.0	......	[g]1.40	[g]1.32	2.05	2.50
Idaho	......	[c]27.1	25.8	37.7	......	[e]13.1	[d]12.2	[f]20.6	......	[c]1.21	1.75	2.85
Washington	......	[e]30.3	29.9	39.0	......	[e]16.1	15.4	18.3	......	[e]1.31	1.57	2.24
Oregon	[h]29.0	26.8	25.2	30.9	[h]24.2	17.8	12.4	14.6	[h]1.46	1.54	1.59	2.08
California	[i]23.2	20.6	21.2	22.5	[i]21.5	[i]12.0	12.8	12.0	[i]1.41	1.47	1.54	1.83
The Territories	[i]28.8	[b]20.6	[d]24.2	......	[d]24.2	[b]17.4	[d]12.8	......	[h]1.46	[e]1.41	......	......
United States	22.8	22.4	22.7	25.5	13.6	13.0	12.9	15.7	1.22	1.24	1.20	1.43

[a] 1 year.
[b] 2 years.
[c] 3 years.
[d] 4 years.
[e] 5 years.
[f] 6 years.
[g] 7 years.
[h] 8 years.
[i] 9 years.

Yield per acre—Continued.

States and Territories.	Buckwheat (bushels).				Potatoes (bushels).				Cotton (pounds).			
	1867-1876.	1877-1886.	1887-1896.	1897-1906.	1867-1876.	1877-1886.	1887-1896.	1897-1906.	1867-1876.	1877-1886.	1887-1896.	1897-1906.
Maine	22.2	21.1	25.8	29.6	113	99	110	153	......	......	......	......
New Hampshire	19.5	19.1	20.8	22.0	120	96	98	106	......	......	......	......
Vermont	20.3	20.7	22.9	23.4	140	107	101	100	......	......	......	......
Massachusetts	14.0	14.0	16.4	17.9	112	95	99	98	......	......	......	......
Rhode Island	[e]15.5	[f]10.4	[d]13.1	......	92	91	108	123	......	......	......	......
Connecticut	17.1	12.7	13.9	17.4	95	79	86	94	......	......	......	......
New York	18.8	14.9	16.2	17.7	96	81	77	80	......	......	......	......
New Jersey	16.5	14.4	14.2	19.3	78	82	78	91	......	......	......	......
Pennsylvania	18.2	14.5	15.1	18.4	89	77	77	79	......	......	......	......
Delaware	[h]18.5	[f]13.4	[h]15.4	16.1	77	71	63	70	......	......	......	......
Maryland	17.0	14.6	14.0	16.5	70	71	70	75	......	......	......	......
Virginia	14.8	12.7	11.3	16.3	67	67	70	72	175	177	155	177
West Virginia	16.8	12.9	14.0	19.0	77	71	70	78	......	......	......	......
North Carolina	[h]17.4	[g]10.0	11.7	14.6	86	71	71	68	164	172	170	207
South Carolina	......	......	......	......	78	65	66	74	154	152	157	189
Georgia	......	......	......	......	[i]82	[i]63	64	63	154	146	151	175
Florida	......	......	......	......	[e]95	[f]68	74	76	128	108	111	121
Ohio	13.8	12.4	13.4	17.0	84	75	66	77	......	......	......	......
Indiana	15.8	[i]12.2	13.0	15.9	75	70	64	73	......	......	......	......
Illinois	14.6	11.9	12.4	15.2	75	78	66	80	......	......	......	......
Michigan	16.5	14.5	13.8	14.3	92	87	72	83	......	......	......	......
Wisconsin	16.5	11.8	12.6	15.4	88	83	77	94	......	......	......	......
Minnesota	16.7	12.5	12.2	15.1	104	99	85	87	......	......	......	......
Iowa	18.1	[i]12.3	12.8	14.8	97	85	73	81	......	......	......	......
Missouri	18.5	[i]13.3	12.1	14.2	80	76	74	76	231	205	210	242
North Dakota	......	[d]8.1	[g]12.1	[d]11.9	......	[e]80	[h]83	94	......	......	......	......
South Dakota			[i]11.9	......			[h]62	82	......	......	......	......
Nebraska	[f]18.9	[i]12.6	10.7	14.8	90	83	63	83	......	......	......	......
Kansas	17.1	12.7	[i]10.5	[f]13.4	98	71	60	75	......	......	......	......
Kentucky	[h]16.1	[f]9.5	[d]12.4	......	70	67	65	67	......	......	......	......
Tennessee	12.4	[i]10.9	11.3	15.6	73	71	64	60	165	190	165	184
Alabama	......	......	......	......	67	72	65	65	152	142	150	166
Mississippi	......	......	......	......	78	69	67	75	185	176	178	208
Louisiana	......	......	......	......	84	[f]63	66	64	212	209	207	244
Texas	......	......	......	......	100	66	66	66	233	190	189	181
Indian Territory	......	......	......	......	......	......	......	[f]73	......	......	......	249
Oklahoma	......	......	......	......	......	......	......	[f]80	......	......	......	240
Arkansas	......	......	......	......	80	80	70	67	217	226	203	215
Montana	......	13.2	[d]13.4	......	......	[e]104	108	144	......	......	......	......
Wyoming	......	......	......	......	......	[e]96	109	133	......	......	......	......
Colorado	......	......	......	......	......	[g]79	92	112	......	......	......	......
New Mexico	......	......	......	......	......	[e]79	72	68	......	......	......	......
Arizona	......	......	......	......	......	[e]64	[i]71	......	......	......	......	......
Utah	......	......	......	......	......	[e]94	103	140	......	......	......	......
Nevada	27.5	......	......	......	[g]104	[g]94	118	144	......	......	......	......
Idaho	......	......	......	......	......	[e]99	116	139	......	......	......	......
Washington	......	22.0	[d]15.0	......	......	[e]119	121	132	......	......	......	......
Oregon	[f]22.3	[f]14.5	[i]17.5	[d]15.5	[h]115	109	92	107	......	......	......	......
California	[h]23.2	[e]20.4	[h]18.8	......	[i]117	97	82	119	......	......	......	......
The Territories	[e]28.8	......	[d]14.0	......	[i]120	[e]111	......	......	......	......	......	......
United States	17.6	14.5	15.3	18.1	90	82	75	86	181	170	172	191

[a] 1 year.
[b] 2 years.
[c] 3 years.
[d] 4 years.
[e] 5 years.
[f] 6 years.
[g] 7 years.
[h] 8 years.
[i] 9 years.

B.

The average yield per acre in the forty years 1867–1906 and the average yield in each decade, for specified crops in the United States, were as follows:

Crop.		1867–1906.	1867–1876.	1877–1886.	1887–1896.	1897–1906.
Corn	bushels	25.2	26.2	25.1	24	25.4
Wheat	do	12.7	12	12.5	12.7	13.8
Oats	do	27.7	27.5	27.8	25.5	30.1
Barley	do	23.4	22.8	22.4	22.7	25.5
Rye	do	13.8	13.6	13.8	12.9	15.7
Hay	tons	1.28	1.22	1.24	1.20	1.43
Buckwheat	bushels	16.4	17.6	14.5	15.3	18.1
Potatoes	do	83.3	90	82	75	86
Cotton	pounds	179	181	170	172	191

C.

Representing the average yield of the forty years 1867–1906, by 100, the relative average yield per acre in each decade was as follows:

Crop.	1867–1876.	1877–1886.	1887–1896.	1897–1906.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Corn	104	100	95	101
Wheat	94	98	100	108
Oats	99	100	92	109
Barley	98	96	97	109
Rye	99	94	93	114
Hay	95	97	95	112
Buckwheat	107	89	93	111
Potatoes	108	98	90	103
Cotton	102	95	96	107

CROP YIELD AND SOIL COMPOSITION.

By Dr. Milton Whitney,
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THE FERTILITY OF THE SOILS OF THE UNITED STATES AS MEASURED BY THE YIELDS OF CROPS.

At the recent conference at the White House on the conservation of our natural resources, Mr. J. J. Hill gave very forcible expression to an idea which is quite commonly held, that the fertility of our soils is being reduced and that they are becoming exhausted. He used three illustrations to prove the point, namely, the yield per acre of wheat in the States of New York, Kansas, and Minnesota. In New York the average yield for the past ten years, he states, is about 18 bushels; during the first five years of this period the yield was 18.4 and during the last five years 17.4 bushels, apparently showing an alarming decrease during a comparatively short time. If, however, he had gone further back into the official records of the Bureau of Statistics of the Department of Agriculture, he would have found that the average yield of the State of New York for the past forty years (1866–1907) is 15.7 bushels, the average yield for each decade since 1866 being 14.1, 15.6, 15.4, and 17.9, indicating an apparent increase instead of a decrease with the average acreage for each decade of 592,584, 743,209, 547,191, and 452,204.

In like manner he called attention to the fact that the average yield for the past ten years in Kansas was 14.16 bushels. For the first half of the period the yield was 15.14 bushels and for the last half 13.18, but the department records show that the average yield for Kansas for the past forty years is 13.9 bushels, so that on the face of it his argument again falls down, but in this case there is another factor which did not enter markedly in the case of New York, namely, that the acreage upon which the estimates of the yield per acre is made has materially changed. The average yield of the four decades is 15.0, 13.6, 12.7, and 14.2, and the acreage for the corresponding decades 372,788, 1,617,317, 2,523,637, and 4,818,335. The development of agriculture in Kansas, as expressed in the increase of nearly 1,200 per cent in wheat acreage, has been in the direction of the semiarid portion of the State and on lands which were formerly not considered suitable for cultivated crops, so the indications are certainly strong that the fertility of the Kansas soils, as expressed by the average yield of wheat, has not declined in the past forty years.

In the case of Minnesota he states that the average yield for the past ten years was 12.96 bushels. For the first half of this period the yield was 13.12 and for the last half 12.8. But the average yield of wheat in Minnesota for the past forty years was only 13.6 bushels. The yield for each decade was 14.4, 13.4, 13.7, and 13.0, with an acreage of 1,309,367, 2,705,898, 3,130,794, and 5,281,253, giving another case where the area upon which the average yield is estimated has been considerably increased.

YIELD PER ACRE OF WHEAT IN THE UNITED STATES.

A careful study of the official records of the Bureau of Statistics of the Department of Agriculture fails entirely to bear out the general impression that the yields are declining in the United States as a whole or in any considerable portion of the area, but on the contrary indicates strongly that the yields as a whole are increasing, although to a slight extent. It is, of course, extremely difficult to draw conclusions from estimates, even with records extending over a period of forty years, in a country which has been rapidly developing and when the basis of the estimates, namely the area, is rapidly increasing and where the seasonal variations are large.

The average yield of wheat in the United States for the past forty years is 12.7 bushels. The four decades show 12.0, 12.5, 12.7, and 13.8, indicating an apparent regular increase in productivity, but at the same time the acreage has increased 21,661,078, 35,060,189, 32,623,809, and 45,540,593, so that it is not safe to draw this inference from the figures above. There are 33 States which have a higher average yield per acre than the United States as a whole and 15 having a lower yield. If proportionately more of the increase in acreage has occurred in the 33 States having above the average yield for the country as a whole, the increase in yield per acre for the United States would be accounted for. This line has not been followed out as it is obvious that we must look further into the facts before any safe conclusions can be drawn as to any change in the fertility of our soils.

AVERAGE YIELD PER ACRE OF WHEAT IN THE SEVERAL STATES.

In the following table the States for which the Bureau of Statistics has full forty-year records (except California, which has records extending over only thirty-nine years) are arranged in the order of the average yield per acre of wheat over this period.

Average yield of wheat, in bushels per acre, for forty years, 1866–1907.

State.	Yield.	State.	Yield.	State.	Yield.
Vermont	18.5	Maryland	13.3	West Virginia	10.6
Maine	16.5	Illinois	13.2	Kentucky	10.5
New York	15.7	Nebraska	13.1	Virginia	9.1
New Jersey	14.5	Indiana	13.1	Arkansas	8.9
Michigan	14.5	Delaware	13.1	Tennessee	8.2
Pennsylvania	14.2	California	12.9	Mississippi	8.1
Ohio	14.1	United States	12.7	Alabama	7.6
Kansas	13.9	Iowa	12.4	Georgia	7.1
Wisconsin	13.7	Missouri	12.2	North Carolina	6.9
Minnesota	13.6	Texas	11.5	South Carolina	6.6

The most obvious fact brought out by this table is that the arrangement shows roughly three geographical groups of States, the Southern States having very small yields, the New England States with New York showing the largest yields (from two to three times as large as the Southern States), and the great wheat States of the Middle West coming in between.

This great difference between the States will be considered later; what concerns us now is the variation in the yield per acre for any particular State or group of States. The average yield for each of the four decades is given in the table prepared by the Bureau of Statistics for each of the States. These yields show a general tendency to increase, but there are fluctuations which make it difficult to draw satisfactory conclusions as the seasonal variations have not been entirely eliminated even over so long a period, and we know that great changes have occurred in the acreage of certain of the States; it is important to see the effect, if any, upon the average yield.

In considering the question of change in the fertility of the land as measured by the yield per acre of crops, it is necessary to have records covering a sufficiently long period to reduce the seasonal variations to a very small amount, and it is unfortunate that we have not available continuous records in this country for more than forty years, either for a State or for any individual farm or constant area of any soil type.

NEW ENGLAND STATES AND NEW YORK.

The nearest approach to this constant acreage and uniformity of yield in several States, where at the same time records of the Bureau of Statistics are available for forty consecutive years, is in what may be taken as two groups of States, namely, Maine, Vermont, and New York; and New Jersey, Pennsylvania, Delaware, and Maryland. In all of these States agriculture is old and in the past forty years there has been relatively very little new land to take up.

In Maine and Vermont the acreage in wheat, at all times small, has been reduced considerably in later years, and the yield per acre has materially increased during the successive decades. It may be argued that this increase in yield per acre is due to the abandonment of the lands less well adapted to wheat, but in New York, with a very much larger acreage but with a much smaller difference in acreage, the yield has increased nearly as much. If we take the figures representing the yield per acre for each of the States for the four decades as an indication only of fertility and regardless of acreage and add them together, we get a factor of relative productivity for the different decades in which the seasonal fluctuations will be more nearly eliminated than if we had used the weighted averages, and while the results show the same order of increase we get a smoother curve.

Reducing these sums to figures approximately equal to the average yields per acre of the several States, by dividing by the number of States, the relative yields of the several decades are represented by the figures 14.6, 15.6, 17.4, and 20.5, indicating a decided and progressive increase in the productivity of the lands.

These States, however, show a remarkable falling off in the total land values and contain many so-called "abandoned" farms, but so far as the production of wheat is concerned this is not due to a decline in fertility or the wearing out of the soil, and the explanation must be sought in changed economic conditions connected with the relative cost of production and other conditions which are outside of the scope of this article.

NEW JERSEY, PENNSYLVANIA, DELAWARE, AND MARYLAND.

The effect of the intelligent reduction of acreage mentioned as a possible factor in increasing the yield per acre of wheat in the New England States and New York can not hold with equal weight with the second group of States above mentioned, as the acreage has varied but little in the States of New Jersey, Pennsylvania, Delaware, and Maryland. Nevertheless by combining the yields per acre as fertility factors for these States, as was done in the last group, the relative order of productivity for the different decades is represented by the figures 12.7, 12.9, 13.4, and 16.0, again showing a regular increase for a group of some of the older States, where the land has practically all been settled for much longer than the forty years.

VIRGINIA, NORTH CAROLINA, SOUTH CAROLINA, GEORGIA, AND ALABAMA.

In these States the average yields per acre have been closely comparable and the acreage not very different either among the States or during the period of forty years. In each case there is an indication of a slight increase of productivity, although both the first and last decades show larger yields than either of the intermediate ones. The relative order of the group of States for the four decades is represented by the figures 7.4, 6.8, 6.9, and 8.7.

OHIO, INDIANA, AND ILLINOIS.

Ohio, Indiana, and Illinois form another group of States having nearly the same acreage and the same yields per acre in which the yield per acre for the past forty years has apparently at least held its own or even increased, the relative productivity of the three States for the four decades being represented by the figures 11.9, 14.2, 13.5, and 13.9.

WISCONSIN, MICHIGAN, IOWA, AND ILLINOIS.

We come now to two groups of States showing some marked differences in acreage in the last forty years. The sum of the average acreage in wheat for the four decades in the first of these groups (Wisconsin, Michigan, Iowa, and Illinois) is 7,330,041, 8,525,988, 5,697,582, and 4,572,012. The relative yield per acre of the group of States for the corresponding decades may be expressed by the figures 12.4, 13.3, 13.8, and 14.3.

It may be argued, as in the case of the New England States, that in restricting the acreage the lands less well adapted to wheat have been first abandoned and the average yield increased in this way.

MINNESOTA, NEBRASKA, KANSAS, AND MISSOURI.

We have another group of closely adjacent States, namely, Minnesota, Nebraska, Kansas, and Missouri, where the sum of the mean acreage for the several decades has been 2,693,576, 7,799,182, 8,654,331, and 14,364,930, while the relative yield per acre of the group may be expressed by the figures 13.8, 12.6, 12.6, and 14, again an apparent increase. The figures for Minnesota and Kansas, it is true, appear to show a slight decrease, but the seasonal variations in both these States are large, so large they are not eliminated in the ten-year periods. For example, in Nebraska in the first and third decades the difference between the highest and lowest yield is actually greater than the average yield for forty years. The larger the groups of States that can be compared, therefore, the better. The relative yield per acre for the eight States in this and the preceding group for the several decades may be expressed by the figures 13.1, 12.9, 13.2, and 14.1. From the data available it is reasonable to assume that the yield per acre in each of these states has increased to some extent, although in four of the States the acreage has increased and in the other four it has decreased.

KENTUCKY AND TENNESSEE.

Kentucky and Tennessee, each with an acreage fairly constant, show an increase in yield per acre, while West Virginia has remained about constant.

OHIO, WEST VIRGINIA, AND INDIANA.

Ohio, West Virginia, and Indiana, with an increasing acreage for the first three decades, represented by the figures 3,503,127, 5,283,871, 5,530,392, and 4,588,086, show a slight increase in fertility, represented by the figures 11.6, 13.3, 12.4, and 13.1.

TEXAS AND ARKANSAS.

Of the other large wheat-producing States, Texas, with an increase of acreage from 119,340 acres in the first decade to 993,206 in the last, has remained practically constant in yield per acre, while Arkansas, with a practically constant acreage, has increased during the past thirty years.

CALIFORNIA AND OREGON.

California, with a fairly constant acreage, is the only one of the States showing an apparent decline in yield per acre, the figures for the several decades being 14.6, 12.9, 12.7, and 11.6. But, it should be observed that during the last decade there occurred two of the lowest yields on record, while in the last year of the last decade the yield per acre was 17.1 bushels, exceeded only by the crop of 1868 of 20 bushels and that of 1870 of 19 bushels. The two middle decades in many of the States show lower yields than the first and last, which indeed is shown in the adjoining State of Oregon, where the yield by decades is 18.6, 17.1, 17.1, and 18.7, and the fact that in the last year of the last decade a yield was obtained exceeded only by two others, makes it seem quite probable that with more data covering a longer period of time California would show no exception to the rule of a slight but gradual increase in productivity as measured by the yield per acre of wheat.

The following table gives the data for the States having records covering less than forty-year periods and more than twenty years, and with not less than five years in each decade:

Average yield of wheat, in bushels per acre, in States having twenty to forty year records.

State or Territory.	First decade.	Second decade.	Third decade.	Fourth decade.
Utah		[a] 17.5	18.8	22.5
Nevada	[b] 21.1	[b] 17.8	19.2	26.9
Wyoming		[a] 17.4	[c] 21.0	23.0
Idaho		[a] 16.9	19.2	23.8
Colorado		[b] 19.2	19.0	24.6
North Dakota		[a] 14.1	[c] 14.0	12.3
Montana		[a] 17.5	20.8	26.7
New Mexico		[a] 13.2	15.6	20.0
Arizona		[a] 13.8	16.2	21.8
Washington		[a] 16.5	17.7	23.3

[a] 5 years. [b] 7 years. [c] 6 years.

The data here are so incomplete in comparison with what has been given, and the question of irrigation in many of these States introduces so uncertain a factor, that the results will not be discussed; while for some of the other States, notably New Hampshire, Massachusetts, Connecticut, Rhode Island, South Dakota, Louisiana, and Florida, the data are so incomplete that no conclusions can be drawn.

If any conclusion is to be drawn from the statistics it can only be that the fertility of our soil, as measured by the average yield of wheat per acre, is increasing.

YIELD PER ACRE OF CORN IN THE UNITED STATES.

The average yield per acre of corn in the United States for the past forty years is 25.1 bushels, the figures for the four decades being 26.1, 24.8, 24.2, and 25.4. It is apparent that the period of forty years with its four decades is too short a time to eliminate or balance the great seasonal variations, and in the country as a whole as well as in the records from most of the States we get a yield above the average in the first and last decades and below the average in the two middle periods. It would appear, then, on the face of it that there has been no decline in fertility as measured by the yield per acre of corn, but it must be remembered that the acreage upon which the estimate of the yield is made has considerably increased, the figures for the several decades being 386,884,000, 634,089,000, 742,909,000, and 879,712,000.

As the estimated average yield per acre is based upon the actual acreage in corn, it is obvious that if the greater portion of this increased acreage occurred in the States having greater average yields than the country at large, the average yield of the United States would be increased, possibly to the extent of masking any change in the fertility, while, on the other hand, if the greatest increase in acreage occurred in the States having a lower average yield, the average yield per acre of the United States would be reduced, so that in themselves the figures above given show nothing as to any change in fertility of the soil of the United States. To arrive at any definite conclusion it will be necessary, as in the case of wheat, to consider the yield of individual States and of groups of States. It may be stated at the outset, however, that for two reasons the figures for corn do not lend themselves so well to a complete solution of this great question as do those for wheat. The average yields per acre of nearly all the States are considerably higher in the first and last decades than in the intervening twenty years, indicating probably profound and long continued seasonal variations.

The acreage in all but New York, Pennsylvania, and California of the large corn-producing States has increased considerably, and in only two of the smaller States, namely, Rhode Island and Maine, has there been a regular and obvious reduction in acreage, so that the influence of intelligent selection of lands to be taken up or abandoned for corn culture can not be considered. However, in the case of wheat it was shown that this had no apparent effect upon the average yields so far as could be determined from the statistics.

YIELD PER ACRE OF CORN IN THE SEVERAL STATES.

The following table gives the States for which forty consecutive years' records are furnished by the Bureau of Statistics, excepting California, which has thirty-nine years' record, arranged according to their average yields per acre:

Average yield of corn, in bushels per acre, for forty years, 1866–1907.

State.	Yield.	State.	Yield.	State.	Yield.
New Hampshire	35.1	Michigan	30.8	Delaware	22.6
Vermont	35.1	Illinois	30.2	Tennessee	22.0
Massachusetts	34.5	Rhode Island	30.1	Arkansas	20.0
Pennsylvania	33.2	California	30.1	Texas	19.1
New Jersey	33.2	Minnesota	29.2	Virginia	19.0
Maine	32.9	Nebraska	28.7	Louisiana	16.7
Ohio	32.9	Missouri	28.3	Mississippi	15.0
Connecticut	32.2	Maryland	26.6	North Carolina	13.3
Iowa	32.2	Kentucky	26.1	Alabama	13.1
Indiana	31.5	West Virginia	25.3	Georgia	11.0
Wisconsin	31.3	Kansas	25.1	Florida	9.8
New York	30.8	United States	25.1	South Carolina	9.7

There are twenty-three States having the same or a higher average yield than the United States and twelve States having a lower yield.

It is obvious that the yield per acre remaining the same, any increase in acreage will have no effect on the average yield for the United States, while an increased acreage in Georgia would counterbalance an increase of nearly three times the acreage in Nebraska, on account of the disparity in the yield and the departure from the average. It has not been deemed wise, however, to attempt to arrive at conclusions as to a change of fertility by such a method of comparison.

NEW ENGLAND STATES.

The acreage in Maine and Rhode Island has materially decreased, while indications are that the yield per acre has slightly increased. The acreage of the four other States has remained fairly constant, while the figures indicate a slight decrease in the yield per acre in New Hampshire and Vermont and a slight increase in Massachusetts and Connecticut. The differences, however, are so slight, as compared with the fluctuations between the decades, that no safe conclusions can be drawn as to any change of fertility. Comparing the groups of States, as was done in the case of wheat, the acreage for the four decades was 2,469,000, 2,627,000, 2,169,000, and 1,951,000, while the relative yields for the four decades may be expressed by the figures[*] 32.6, 32.5, 34.4, and 34.2, indicating if anything a slight increase in fertility of the soils as measured by the yield per acre of corn.

NEW YORK, PENNSYLVANIA, AND NEW JERSEY.

The acreage in New York, Pennsylvania, and New Jersey, has varied but little in the forty years, and the average yields indicate neither an increase nor decrease.

MARYLAND, DELAWARE, AND VIRGINIA.

The relative yield in the four decades of Maryland, Delaware, and Virginia may be expressed by the figures 21.8, 21.0, 20.9, and 27.0; the total acreage being 16,145,000, 24,973,000, 28,038,000, and 26,243,000.

NORTH CAROLINA, SOUTH CAROLINA, GEORGIA, FLORIDA, AND ALABAMA.

The relative yield for North Carolina, South Carolina, Georgia, Florida, and Alabama for the four decades may be expressed by the figures 12.3, 10.8, 11.4, and 11.3; the total acreage being 66,993,000, 86,117,000, 102,619,000, and 113,809,000.

OHIO, INDIANA, ILLINOIS, MICHIGAN, WISCONSIN, AND MINNESOTA.

The relative yield for Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota may be expressed by the figures 31.7, 30.2, 29.0, and 33.1; the acreage being 126,441,000, 177,378,000, 162,838,000, and 193,646,000.

So far the data do not permit one to say that there has been an increase in fertility as measured by the yield per acre of corn, save possibly in the New England States, and certainly there is no justification for saying there has been a decrease. We now come to a group of States, however, which show a decided decrease, although a full analysis of the original data does not justify such a conclusion.

NEBRASKA AND KANSAS.

The average yield of Nebraska and Kansas may be expressed by the figures 33.3, 32.5, 25.7, and 24.8. These two States show by far the greatest increase in corn acreage of any of the 35 States under consideration. The basis for the estimate of the average yield per acre in the last decade, namely, the acreage, was 700 per cent larger in Kansas and 2,500 per cent larger in Nebraska than in the first decade, yet we have in Nebraska the average yield of 32 bushels on 3,011,000 acres in the first decade to compare with the average yield of 27.8 bushels on 77,213,000 in the last decade, and nearly as great a disparity in the case of Kansas. The combined acreage for the four decades is 12,625,000, 63,621,000, 110,130,000, and 154,177,000.

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[*] These figures are straight averages of the yields per acre as fertility factors in which each State has equal weight. This method is only allowed when the acreage and yields per acre of all the States are of the same order or do not vary much. The weighted averages in this case, when the sums of the acres and of the bushels of all the States are used, are 33.1, 32.6, 34.9, 34.6, showing the same order of increase. The former method lends itself rather better for the purposes of this investigation.

However, taking the data as they stand, we find, in going back to the original data, three years of crop failure in Kansas in the third decade, the average yields being for 1887, 14.6 bushels; 1890, 15.6; and 1894, 11.2, the highest yield being in 1889, 35.3 bushels. In the last decade there were three years of very low yields, 1897, 18.0 bushels; 1898, 16.0; and 1901, 7.8. The last five years of the last decade show four years well above the average for the forty years, so that here again there is no apparent justification for assuming a decrease in the average fertility of the soil as measured by the yield of corn. Similarly, in the third decade, Nebraska shows a yield of only 6.0 bushels in 1890, while in the last decade are two very low yields and four out of the last five years show a considerably larger yield than the average for the forty years.

IOWA AND MISSOURI.

Adjoining Kansas and Nebraska on the east are the States of Iowa and Missouri, where there has likewise been a considerable increase in acreage, although not nearly so large as in the first-named States. The total acreage of the two States for the four decades is 58,188,000, 117,138,000, 141,778,000, and 148,721,000. The average yields may be expressed by the figures 31.5, 29.4, 30.3, and 30.2.

MISSISSIPPI, LOUISIANA, TEXAS, AND ARKANSAS.

The average yield of Mississippi, Louisiana, Texas, and Arkansas may be expressed by the figures 20.9, 17.2, 16.9, and 17.5; the total acreage being 40,408,000, 71,225,000, 91,561,000, and 110,791,000. Texas and Arkansas both show a large increase in acreage and a moderate decline in yield, but an analysis of the figures shows reasons for this in great seasonal variations, as in the case of Kansas and Nebraska, and it is not safe to conclude from the data that the fertility of the lands as measured by the yield per acre of corn of any one of these four States has declined. Considering the large increase in acreage and the wide variations in yield per acre due to climatic conditions, it would take a considerably longer period of observations to determine definitely the question of any change in fertility of the soils. In other words, it may reasonably be assumed that for the past forty years the fertility of the soils of this group of States has remained fairly constant.

CALIFORNIA.

The average yield for California may be expressed by the figures 37.4, 28.2, 29.9, and 29.9; the acreage being 326,006, 1,101,000, 1,127,000, and 562,000.

In the last half of the last decade, during four years the average yields were well above the average for the thirty-nine years and are comparable with the yields of the first decade, with the exception of the very large yields of 1868, 45 bushels; 1869, 41.4 bushels; and 1873, 41 bushels; so that it would not be safe to conclude that there has been any decline in the fertility in the soils of the State in the past thirty-nine years as measured by the yield per acre of corn as indicated by the average yields of the four decades, any more than it would be safe to assume an increase during the past thirty years as also indicated by the decade figures.

Summing up the data furnished by the Bureau of Statistics on the yield of corn per acre, it is unsafe to draw any conclusion other than that the fertility of the soil of the United States as measured by the yield per acre of corn has remained practically constant, with, if anything, a slight tendency to increase. The data are, however, much more difficult to draw conclusions from than in the case of wheat, partly because of the wide seasonal fluctuations and partly on account of the large increase in acreage in most of the larger corn States. The following table gives the percentage of increase in the acreage of the 24 States showing an increase, which displays at once the difficulty of drawing conclusions from figures where the basis of the figures which are to be compared has such wide variation:

Percentage of increase in corn acreage from 1866 to 1907 in the several States where material increase has occurred.

State.	Percentage of increase.	State.	Percentage of increase.	State.	Percentage of increase.
Nebraska	2,500	Missouri	130	Indiana	54
Kansas	700	United States	127	Mississippi	50
Texas	356	Michigan	124	Tennessee	49
Minnesota	409	Louisiana	121	Alabama	46
Arkansas	190	Virginia	87	Illinois	36
Iowa	179	South Carolina	85	Maryland	26
Florida	153	North Carolina	75	Ohio	21
Wisconsin	152	Georgia	72		
West Virginia	133	Kentucky	56		

With the full analysis of the data for the two important crops of wheat and corn, it seems unnecessary for the purpose of this report to discuss the data relating to oats, barley, rye, hay, buckwheat, potatoes, and cotton, especially as a casual observation of the data furnished by the Bureau of Statistics on these crops shows the same general facts and would add nothing new to this discussion. The only inference, therefore, which can be drawn from the statistics is that the productivity of the soils of the United States has not declined in the past forty years, but that on the contrary it has increased.

THE FERTILITY OF THE SOILS OF EUROPE AS MEASURED BY THE YIELD OF CROPS.

In considering so serious and fundamentally important a question as the possible loss of soil fertility and the wearing out of our soils, and in order to show conclusively from the data submitted by the

Bureau of Statistics on our crop yields that the common impression on this subject is erroneous, it is well to review the facts presented by the experience of other countries.

In the European countries are older agricultural soils than in the United States, in that they have been settled and have been developing their present agriculture for a thousand years or more, while many parts of our great West have seen all of their agricultural development in the past forty or fifty years, since the great transcontinental railway systems were established.

If the views which have been taught for the past seventy years be correct, that continued cropping gradually exhausts the soil and tends to make it unproductive through loss of mineral plant food, we should expect to find a marked and fundamental difference between the soils of the United States and the older soils of Europe, as shown either in the yield of crops or in the chemical composition of the soils. We will first review such data as are available regarding the yield of crops and then consider the chemical data.

The following is given as the yield per acre of wheat in bushels in several European countries and in the United States for the ten years (1897–1906) in the Yearbook of the Department of Agriculture for 1907, page 620:

Average yield of wheat, in bushels per acre, of various countries.

United Kingdom	32.2
Germany	28.0
France	19.8
Austria	17.8
Hungary	17.6
United States	13.8
Russia (European)	9.3

It is apparent that the older soils of Europe are producing more than the newer soils of the United States. Have they always done so, or are the yields increasing there as they are with us, and has the increase gone farther with the longer time and the greater population and the necessities incident to the larger number of people to support?

Kellermann has made a most exhaustive investigation and report upon the increase in crop production in Germany.[a] He gives the yields per acre of a large number of estates which have been handed down from father to son, some of the records going back to the middle of the sixteenth century. Three cases only will be given here, which show the general trend of the information he was able to gather.

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[a] Landw. Jahrb. 35, 289 (1906).

Yield of cereals in Schmatzfeld, Germany.

[Reduced to bushels per acre.]

Year.	Wheat.	Rye.	Barley.	Oats.
1552-1557	12.5	13.2	14.2	14.8
1660	......	12.8	8.3	12.3
1670	14.6	17.2	16.1	17.4
1822	18.7	24.3	33.7	26.2
1825	18.1	20.0	28.1	32.5
1830	18.7	21.2	35.6	46.2
1840	25.6	30.0	31.6	45.5
1850	28.7	33.1	39.3	50.1
1860	35.3	39.3	32.9	62.9
1870	27.6	20.4	43.8	46.6
1886	37.9	28.9	43.2	66.6
1887-1896	40.0	29.6	47.6	59.7
1897-1904	45.1	34.0	50.4	69.1

The period from 1552 to 1557, apparently the average for those years, gives a yield of wheat of 12.5 bushels per acre; in 1670 there is a record of 14.6 bushels; in 1822 of 18.7 bushels; in 1825 of 18.1 bushels; in 1840 of 25.6 bushels; in 1850 of 28.7 bushels; in 1860 of 35.3 bushels; in 1897 of 45.1 bushels; an increase in those three hundred years from 12.5 bushels in 1552 to 45.1 bushels in 1897, the record showing a regular increase with a few fluctuations which are probably due to seasonal conditions.

Rye has increased during the same time from 13.2 bushels in 1552 and 12.8 bushels in 1660 to 30 bushels in 1840 and 34 bushels in 1897.

Barley has increased from 14.2 bushels in 1552 or 8 bushels in 1660 to 16.1 bushels in 1670, and finally to 50.4 bushels in 1897.

Oats have increased from 14.8 bushels in 1552–1557, the first record, to 69.1 bushels in 1897–1904, which is the last record.

Yields of cereal crops on a second German estate, Rittergut Trebsen, near Leipzig.

[Reduced to bushels per acre.]

Year.	Wheat.	Rye.	Barley.	Oats.
1756-1765	26.41	15.91	14.25	23.03
1766-1775	13.25	12.33	21.71	23.48
1776-1785	16.63	14.47	20.44	23.45
1786-1795	13.98	13.67	16.77	19.16
1796-1800	13.89	15.36	15.16	17.90
1814-1816	15.28	15.68	25.41	25.72
1820-1822	16.90	19.14	18.28	26.36
1825-1834	21.04	21.63	30.19	31.83
1835-1844	33.40	27.92	36.66	46.54
1845-1849	25.51	28.75	......	56.25
1883-1892	27.03	23.06	30.95	44.64
1893-1894	29.85	28.36	30.95	54.74
1895-1899	35.85	30.45	35.39	51.15
1900-1904	36.14	32.52	43.23	57.80

From this estate apparently even more continuous records are given in five and ten year periods from 1756 to 1904. The average yield of wheat in the first period of which we have a record, 1756–1765, is 26 bushels; in the next period, 1766–1775, it is 13 bushels; and from that time a gradual increase up to 1900–1904, when it was 36 bushels. Rye increased similarly by regular steps from 15.91 bushels to 32.52 bushels. Barley from 14.25 bushels to 43.23 bushels. Oats from 23.03 bushels to 57.80 bushels.

Yield of cereals on the soils of Tellow.

[Reduced to bushels per acre.]

Year.	Wheat.	Rye.	Barley.	Oats.
1800-1810	21.15	14.64	19.80	17.22
1810-1820	20.02	11.76	20.92	13.44
1820-1830	23.25	17.76	21.29	14.84
1830-1840	18.82	15.04	16.37	13.86
1840-1850	23.10	19.84	20.83	27.58
1850-1855	26.40	23.12	32.75	33.46
1855-1860	25.27	24.16	27.71	34.44
1860-1865	29.77	30.48	37.85	44.52
1865-1870	27.45	26.48	36.17	55.72
1870-1875	29.92	28.32	35.71	51.88
1875-1880	28.12	24.32	29.38	39.48
1880-1885	25.57	25.12	36.45	45.08
1885-1894	35.70	29.52	41.06	43.96

On this estate from 1800 to 1894 in ten-year averages wheat increased from 21.15 to 35.70 bushels, rye from 14.64 to 29.52, barley from 19.8 to 41.06, and oats from 17.22 to 43.96.

Kellerman throughout cites many well-known authorities and refers to many sources of information, and concludes his article with this remarkable statement:

> If we now make a brief survey of the results obtained in the foregoing, we must affirm that the development of the yields of cultivated soil since the beginning of the past century presents a very pleasing picture, not only that agriculture, by absolute addition to the acreage of 30 to 35 per cent and decrease in fallow from 35 to 4½ per cent, has tried to meet the growing needs of the nation for food, but above all that it has shown how to gain from the soil gradually 2½ times as much per unit of surface as formerly.

The same facts have been brought out by Steinbrück,[a] who cites many cases of individual farms from records going back for one hundred years or more.

The French minister of agriculture[b] gives the average yield per acre of the principal cereal crops in France from 1815 to 1876, which, reduced to bushels per acre and ten-year averages, is as follows:

Yield of cereals in France.

[Reduced to bushels[c] per acre.]

Year.	Wheat.	Rye.	Barley.	Oats.
1815-1824	11.86	10.10	14.45	17.12
1825-1834	13.44	12.34	14.64	17.78
1835-1844	14.30	13.01	15.92	20.10
1845-1854	15.14	13.09	18.12	22.33
1855-1864	15.90	14.11	19.90	24.93
1865-1874	15.81	14.65	19.75	24.49
1875-1876	16.60	15.71	19.00	23.61

[a] Der Boden und die landwirtschaftlichen Verhältnisse des Preussischen Staates, vol. 7, p. 799 (1906), edited by August Meitzen.

[b] Bull. Min. Agr. Comm. France. Récoltes des Céréales et des Pommes de Terre de 1815 à 1876, pp. 456–459 (1878).

[c] Bushels of capacity. Statistics for the ten years 1897–1906 indicate that the average weight of a bushel of wheat in France is 60.0 pounds, of a bushel of rye 56.1 pounds, of a bushel of barley 49.6 pounds, and of a bushel of oats 36.5 pounds. The statistics for France on p. 39 are in the bushels of weight customarily employed in the United States (wheat 60 pounds, rye and corn 56 pounds, barley 48 pounds, oats 32 pounds). The difference is greatest in oats, the average yield of which, as given in this table, is on a basis some 14 per cent lower than in tables on p. 39, covering later years. Comparisons between these tables should not be made without making allowance for this.

Wheat has increased from 11.86 to 16.60 bushels; rye, from 10.1 to 15.7; barley, from 14.4 to 19; oats, from 17.12 to 23.61. The great increase in the yield of cereal crops for France is prior to 1860.

CEREAL PRODUCTION OF EUROPE.

Quite recently the Bureau of Statistics of this department has published a report on the cereal production of Europe [a] for the past twenty years or so. (See Appendix A.)

The following table as given in this bulletin summarizes the yield per acre as given in detail in the tables in the appendix to this report, in five-year periods.

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[a] Cereal production of Europe, by Frank R. Rutter, editorial assistant, Bureau of Statistics, Bull. 68 (1908).

Average annual yield of grain, by countries and by five-year periods.

Country.	Wheat.				Rye.				Barley.				Oats.				Corn.			
	1886-1890.	1891-1895.	1896-1900.	1901-1905.	1886-1890.	1891-1895.	1896-1900.	1901-1905.	1886-1890.	1891-1895.	1896-1900.	1901-1905.	1886-1890.	1891-1895.	1896-1900.	1901-1905.	1886-1890.	1891-1895.	1896-1900.	1901-1905.
Austria-Hungary:	*Bu.*	*Bu*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*
Austria	15.9	16.1	16.3	18.5	15.8	15.7	15.9	18.6	20.1	21.3	20.8	23.7	24.3	25.1	25.5	26.7	19.5	19.9	18.9	18.5
Hungary	17.6	19.1	16.7	17.9	15.6	16.9	16.3	17.6	17.9	21.8	22.1	22.5	20.6	25.7	30.1	30.1	18.5	23.2	22.6	19.3
Winter	17.9	19.3	16.8	18.0	15.7	17.0	16.4	17.7	18.2	20.9	20.9	22.3	......	......	......	......	......	......	......	......
Spring	12.6	14.8	13.0	13.2	13.0	14.9	13.8	13.6	17.9	21.0	22.2	22.5	......	......	......	......	......	......	......	......
Belgium:																				
Winter	27.1	27.8	29.7	34.0	25.4	28.9	30.1	34.0	40.8	40.4	43.6	52.0	49.8	50.0	56.8	64.7	......	......	......	......
Spring	21.8	24.5	[a]22.7						33.6	33.7	35.8	41.0								
Denmark	35.8	38.7	41.0	40.2	24.6	26.7	25.8	26.8	29.7	30.4	30.9	34.0	32.0	33.8	35.5	35.9	......	......	......	......
France	17.8	17.7	19.3	20.2	16.4	17.9	17.1	16.8	21.9	21.5	22.5	24.0	30.2	28.7	30.1	32.0	19.3	19.1	19.0	19.4
Germany	20.3	23.3	27.0	28.2	16.0	19.9	23.0	24.9	24.0	28.9	[l]30.7	......	33.2	37.7	45.0	47.1	......	......	......	......
Winter	21.4	23.5	27.3	28.1	16.1	20.0	23.2	25.1	29.0	33.8	[l]37.8	......								
Spring	17.8	21.3	[a]23.3	28.0	12.1	15.7	16.8	17.5	23.9	28.8	31.8	34.3								
Italy	[b]12.1	11.2	[c]12.8	13.1	[b]12.7	12.3	......	......	[b]13.4	10.8	[c]13.2	......	[b]17.0	16.2	......	......	[b]15.9	15.1	[c]16.5	20.2
Netherlands	28.1	27.2	29.8	32.5	22.6	23.4	24.9	25.8	42.4	43.1	45.2	48.0	45.9	46.1	50.8	53.9	......	......	......	......
Winter	......	[d]28.0	29.8	32.4	......	[d]24.7	24.9	25.9	40.4	47.5	48.0	50.7								
Spring	......	[d]28.3	30.0	35.3	......	[d]20.8	20.3	22.8	34.7	35.7	38.1	40.8								
Norway	24.3	27.9	26.7	[e]22.2	27.9	27.8	27.7	25.8	33.0	33.0	34.5	28.9	40.6	44.4	41.0	33.9	......	......	......	......
Roumania	15.3	16.2	13.1	18.3	13.8	16.1	13.4	18.7	13.3	17.0	13.7	18.5	18.0	18.5	16.0	23.0	14.4	14.6	14.0	13.3
Russia (total)	......	[f]10.3	8.7	10.3	......	[f]12.0	11.2	11.7	......	[f]14.4	12.4	14.2	......	[f]20.8	18.9	20.0	......	[f]11.8	13.5	13.7
Winter	......	[f]12.9	10.6	13.9	......	[f]12.1	11.3	11.8												
Spring	......	[f]9.2	8.0	9.0	......	[f]10.2	9.4	9.5												
Russia, European	[g]7.9	8.9	8.4	10.3	[g]9.5	10.3	11.3	[h]12.2	[g]11.0	13.7	12.3	14.2	[g]15.1	17.7	18.6	20.0	......	[m]13.9	13.5	13.6
Winter	[g]11.1	11.2	10.6	13.9	[b]9.4	10.4	11.3	11.8												
Spring	[g]6.8	7.9	7.5	8.8	[b]4.8	8.0	8.2	8.9												
Servia	......	[i]11.1	[j]13.9	12.6	......	[i]8.9	[j]13.5	9.9	......	[i]11.1	[j]16.4	13.9	......	[i]12.5	[j]24.9	14.7	......	[i]13.8	[j]22.2	13.4
Winter	......	[i]11.4	[k]15.2	[h]12.8	......	[i]9.8	[k]14.6	[h]11.2												
Spring	......	[i]8.4	[k]10.8	[h]7.9	......	[i]6.8	[k]13.1	[h]8.2												
Spain	[b]8.8	[d]11.6	10.8	13.0	[b]10.5	[g]11.6	10.9	12.6	[b]10.1	[f]20.4	16.1	18.9	......	[f]15.3	18.0	20.8	[b]24.3	[f]21.4	19.1	22.5
Sweden	[b]23.2	23.5	26.1	25.0	[b]22.4	21.5	21.9	22.2	[b]27.0	25.0	25.2	24.6	[b]32.0	29.8	28.1	27.7	......	......	......	......
Winter	[b]23.4	23.7	26.5	25.3	[b]22.5	21.6	22.0	22.3												
Spring	[b]20.6	21.3	21.2	22.0	[b]16.3	17.2	16.7	17.5												
United Kingdom	30.4	29.0	32.8	31.7	......	......	......	......	33.9	34.2	35.0	34.3	41.8	43.5	43.4	44.7	......	......	......	......
Great Britain	30.4	29.0	32.7	31.7	......	......	......	......	33.7	33.8	34.6	33.6	39.3	39.6	39.8	40.5	......	......	......	......
Ireland	27.9	30.7	32.0	34.6	24.1	26.2	24.8	27.1	36.4	39.7	40.2	42.2	47.6	53.3	53.0	56.7	......	......	......	......

[a] Average, 1896-1899. [b] 1890. [c] 1896. [d] Average, 1892-1895. [e] Average, 1902-1905. [f] Average, 1894-1895. [g] Average, 1886-1890. [h] Average, 1901-1904. [i] 1893. [j] Average 1897-1900. [k] Average, 1897 and 1900. [l] Average, 1896-1898. [m] Average, 1893-1895.

Commenting on this data Rutter has the following to say:

AVERAGE YIELD OF GRAIN.

Wheat.—On comparing the area under wheat in northwestern Europe in 1905 with the average crop during 1901–1905, it appears that the average yield per acre exceeds 25 bushels; in southwestern Europe the average yield is only 16 bushels per acre, and in eastern Europe but 12 bushels. For Europe as a whole the average yield is slightly under 14 bushels per acre.

It appears, therefore, that the average yield per acre is highest where wheat culture is least generally practiced and where the acreage under grain shows the smallest increase. In other words, the extension of the wheat area is most marked where the average yield per acre is lowest.

This condition holds true as regards individual countries as well as the larger divisions of Europe. The United Kingdom, Belgium, the Netherlands, and Denmark are at the same time the four countries in which the wheat acreage during the last twenty years has shown the largest reduction and the four countries which show the largest yield per acre. In each of these countries the acreage under wheat has fallen at least one-fifth in amount, while in each of them over 30 bushels per acre has been harvested on an average during the last five years.

At the other end of the series stands European Russia, in which the increase in acreage during the twenty years was no less than 60 per cent, while the average yield per acre was little more than 10 bushels.

Between these two extremes the relation pointed out between yield and acreage has been by no means so constant, but the divergence is not sufficiently marked to affect the general correspondence. In Sweden, for instance, the acreage under wheat has shown a considerable increase, while the average yield per acre is high, nearly 25 bushels per acre. On the other hand, in Spain the low average yield, 13 bushels per acre, has been accompanied by a small increase in the acreage and the crop.

That the extent of wheat culture should vary inversely as the average yield per acre, or, in other words, that where the results are best the smallest areas are devoted to wheat, seems at first sight paradoxical. It must be remembered that a high average yield, such as shown in the Teutonic countries of Europe, presupposes intelligence on the part of the farmers and valuable land justifying a large outlay of labor and capital. These conditions are much more favorable to the growth of crops requiring intensive cultivation than to grain crops, which give the highest profit when grown on new land on a large scale. Low average yields, if obtained at a low cost of production, produce a greater aggregate profit than can be obtained from grain crops on the smaller tracts in northwestern Europe, where the high price of land necessitates its use in intensive culture. (See Table 5. This table contains unweighted averages of the yearly average yields shown later in the detailed tables.)

Rye.—The yield of rye is highest in Belgium, where during the five years 1901–1905 an average of 34 bushels per acre was obtained. After Belgium come Ireland, Denmark, the Netherlands, Norway, and Germany, in all of which an average yield of from 25 to 27 bushels per acre was obtained. The lowest average yield per acre during the same years was obtained in Servia, 10 bushels per acre, while in European Russia the average yield was slightly more than 10 bushels and in Spain 13 bushels per acre.

Barley.—Of barley, as of rye, the highest average yield per acre during the last five years was obtained in Belgium, in which more than 50 bushels per acre was grown on an average, while the average yield of winter barley alone was 52 bushels per acre. In the Netherlands the average yield was only slightly lower, amounting to 51 bushels per acre for winter barley and 48 bushels for barley of both kinds. Outside of these two countries barley is grown principally as a spring crop; and if that variety alone be considered, Ireland, with 42 bushels per acre, shows the highest average yield. In Germany, Denmark, and Great Britain the average yield per acre is 34 bushels. The lowest average yields per acre recorded are shown by the statistics of European Russia and Servia, according to which but 14 bushels per acre were raised during each of the five years under review.

Oats.—Belgium records an average yield of oats during the five years 1901–1905 of no less than 65 bushels per acre, while Ireland produced 57 bushels and the Netherlands 54 bushels. The smallest average yield per acre recorded is that of Servia, where only 15 bushels were obtained, and European Russia, with 20 bushels.

Corn.—The variations in the average yield per acre of corn are far less marked than the variations in the grains already considered. The almost total absence of its culture from any country included in the northwestern division eliminates the very countries where intensive culture is practiced. The highest yield recorded in 1901–1905 was 22½ bushels per acre in Spain, while the lowest, between 13 and 14 bushels, was obtained in Roumania, Servia, and European Russia.

It is evident from an inspection of all available statistics here cited that the fertility of the older soils of Europe as measured by the yield of cereal crops is fully as great or greater than that of the soils of the United States, and also that the yields have very materially increased during the past century, seemingly much faster than in this country. So far as can be judged from the rather meager records of early days, the yield of cereal crops in the older settled countries of northern Europe at or before the beginning of the last century was not very different from the yields in Russia (still sparsely settled) and in the United States at the present time.

CHEMICAL COMPOSITION OF THE SOILS OF EUROPE AS COMPARED WITH THOSE OF THE UNITED STATES.

It remains now to see if the longer occupation and larger yields of the European countries have materially affected the chemical composition of the soils and sensibly reduced the amount of the mineral plant-food elements. Rocks vary greatly in their ultimate chemical composition, according as one or more of the common minerals predominates, which also gives the essential character to the rock. Soils vary in ultimate chemical composition as the rocks from which they are formed vary and, according to the mode of their formation, are generally more complicated than the rocks with respect to the minerals they contain. It is as difficult, therefore, to compare soils from the chemical composition, unless the type is given, as it would be to compare rocks from the data alone unless the character of the rock were known. As the science of soil classification and soil surveying is new and not on an international basis, it is impossible to compare soils from different countries in any classified or systematic way. The best that can be done, therefore, is to present all the available analyses from a few countries and see if the range in composition is about the same in one as in the others. This method has been followed in the present report, and without attempting to make a selection, and recognizing the unsatisfactory nature of averages with such variable data, all analyses of soil by acid digestion available in the literature in regard to Great Britain, France, Germany, and the United States, in the past eighteen years are given in Appendix B accompanying this report, embracing 1,945 analyses from the United States, 278 from Great Britain, 1,565 from France, and 444 from Germany, or a total of 4,232 analyses.

It must be remembered that the aggregate area of the three countries selected include only a part of the continent of Europe. The total area of Europe is estimated at 3,550,000 square miles, according to Rohrbach, and 3,760,000 according to Wagner-Supan; of continental United States at 2,974,159 (land area) square miles. The area in square miles of the European countries selected for a comparison of the chemical composition of the soil with those of the United States covers only about one-sixth of the continent. The areas, as given in the Statesman's Yearbook, are as follows:

Great Britain and Ireland:		
England	50,848	
Wales	7,467	
Scotland	30,405	
Ireland	32,360	
		121,080
Germany		208,780
France		207,054

The land area in square miles of some of our own States with which these figures might perhaps be compared are:

Texas	262,398
California	156,092
Minnesota	80,858
Missouri	68,727
Illinois	56,002
Alabama	51,279
Florida	54,861
New York	47,654
Pennsylvania	44,832

The method of sampling the soil of a field is not refined, and the chemical methods of determining the small amounts of potash, phosphoric acid, lime, and magnesia in such samples give such variable results, even with the same method on the same sample with the same or with different analysts, that it is unsafe to draw conclusions from slight differences in actual amounts shown even when the differences are proportionally large.[a] It is safer to consider the general range in values for the different localities.

One can not but conclude from the inspection of these data that the chemical composition of the older and longer-used soils of Europe, as regards the principal mineral plant-food elements, is essentially the same as that of the soils of our own country, thus disposing of the fallacious doctrine that soils wear out through loss of plant food by continuous cropping, at least in finite time and to an extent which can be recognized by our methods of observation.

The differences in the chemical composition of the mineral portion of soils as shown by the analyses can not be correlated in general with differences in crop yields; in other words, the fault lies not with the

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[a] Note the results of the analyses of 73 samples from a field of approximately 250 hectares (617 acres) in St. Viand, France, given in one of the tables in the appendix to this report, where the potash varies from .07 to .51 per cent; phosphoric acid from .03 to .10; and lime from .05 to .47 per cent. Of the 1,565 analyses reported from France there are only 69 cases, and most of these in one canton, where the potash falls below .07 per cent—the minimum found on this field—and 51 cases where it goes above .51 per cent. So that it may be said that the variation in the composition of the soil in this single field, as regards potash, is almost as great as the variation in the soils of France.

For a number of years it has been the practice for the referee on soils of the Association of Official Agricultural Chemists to submit carefully prepared samples of soils to various analysts for analysis according to prescribed instrucmethods of analysis, but rather with the uncertainty regarding the interpretation of such results. There are, in fact, no general significant differences in soil composition as regards the mineral matter, but there are, as we shall see, great and significant differences in the chemical composition of the organic constituents of soils.

An examination of the records of the analyses from 592 localities in the Department of Aisne, France, shows that in 407 cases, or 68 per cent, phosphoric acid is the same or higher in the soil than in the subsoil, and in 278 cases, or 47 per cent, potash is the same or higher in the soil than in the subsoil. The same holds true in general of the soils of this country.

The researches of several experiment stations throughout the world and the investigation of our engineers on the amount of material

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tions as to methods of procedure. The following tables give a few of the results of these comparative tests:

Soil sample No. 2.

[Provisional method: Thirty-six hours' digestion.]

Analyst.	K_2O.	Na_2O.	P_2O_5.	CaO.	MgO.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
A	....	....	0.429	....	....
B	0.397	0.76	.480	0.585	0.519
C	.470	.155	.486	.521	.407
D[a]	.275	.280	.580	.360	.360
D[b]	.340	.140	.500	.410	.390
D[c]	.450	.140	.530	.430	.400
E[d]	.330	.125	.600	.430	.375
F	.49	....	.16	.60	....
G	.44	....	.48	....	....
H	.48	....	.47	....	....

[a] Digestion in Snyder flask.
[b] In platinum flask and condenser.
[c] In platinum bottle, stoppered.
[d] Reported as dried at 110° C., figured to original soil by reporter.

(Bulletin No. 43, Bureau of Chemistry (1894), p. 33.)

Phosphoric acid and potash calculated as per cent of the dried fine earth.

[Official method: Ten hours' digestion in HCl of 1.115 sp. gr.]

Analyst.	K_2O. Sample No.—				P_2O_5. Sample No.—			
	1.	2.	3.	4.	1.	2.	3.	4.
A	0.350	0.154	....	....	0.447	0.268	0.409	0.230
B	....	....	....	....	.420	.210	.462	.244
C	.345	.112	0.380	0.04	.430	.117	.449	.095
D	.354	.235	.396	.225	.324	.201	.421	.267
E	.200	....	....	....	.510	....	....	....
F[a]	.373	.179	.365	.175	.451	.172	.396	.193
F[b]	....	....	....	....	.412	.185	.383	.190
G	.210	.130	.220	.100	.400	.210	.500	.220
H	.304	.125	.286	.158	.425	.163	.422	.176

[a] Gravimetric. [b] Volumetric.

(Bulletin No. 47, Bureau of Chemistry (1896), p. 36.)

carried in solution and in suspension in our principal rivers and by the wind establishes the fact, as above stated, that loss through normal leaching removes far more mineral plant food than do cultivated crops. In cropping soils, therefore, and removing the crop from the land we remove an inconsiderable amount of mineral material compared with normal losses to which the soil is adjusted through natural laws which are now for the first time being understood.

It seems safe to assume from the foregoing data that the soil (given a sufficiency of water to supply growing plants) is the one indestructible, immutable asset that the nation has. It is the one resource which can not be exhausted—that can not be used up. If the coal and iron give out, the soil can be depended upon to produce food, light, heat, and habitation not only for the present population, but for an enormously larger one. This will become more evident as we discuss the function of the soil as related to crop production. It may be abused and the yield will quickly decline, and it is the large num-

Phosphorus soluble in fifth normal nitric acid.

[Parts per million in dry soil.]

Analyst.	No. 1.	No. 2.	No. 3.	No. 4.
A[a]	15.0	8.0	5.0	158.0
A	22.0	15.0	10.0	175.0
A[b]	18.0	10.0	5.7	158.0
A	18.0	11.0	6.0	158.0
A[c]	14.4	7.4	4.4	165.5
A	14.0	7.4	4.8	162.0
B	13.4	5.8	3.6	155.5
B	12.9	6.1	2.8	154.5
C	14.0	7.7	3.1	163.4
D	10.6	5.7	3.6	145.6
D		5.6		
E	16.6	9.7	6.4	157.1
F	31.7	15.2	25.5	167.4
G	14.4	7.8	4.8	165.4
G	14.6	7.8	4.8	166.0

[a] Work done according to directions sent out.
[b] Baking of residual omitted.
[c] Baking omitted and phosphorus determined by Kentucky method.

(Bulletin No. 105, Bureau of Chemistry (1907), p. 144.)

Potassium soluble in fifth normal nitric acid by official method.

[Parts per million in dry soil.]

Analyst.	No. 1.	No. 2.	No. 3.	No. 4.
A	99.2	130.0	141.7	236.0
A	88.7	135.9	139.8	233.1
B	113.0	128.0	188.0	276.0
C	95.5	127.9	135.5	234.4
D	89.3	107.9	120.8	189.1
E	91.3	136.0	142.5	244.9
E	96.1	133.8	139.8	249.9

(Bulletin No. 105, Bureau of Chemistry (1907), p. 144.)

ber of such individual failures that forms the basis for the impression that soils wear out by continuous cropping through loss of plant food. We do not notice so clearly the compensating successes which, as we have seen on the average for the past forty years, have rather more than counterbalanced the failures. To produce its best the soil must be thoroughly understood and properly handled. The proper handling may come from long experience on the same soil, as with the English and German farmers, but even then they have benefited greatly by the scientific work that has been done by individuals and experiment stations. In our own country we have not the general experience gained by long residence on the same land. We have not had the pressing necessity for intensive cultivation, and we have, therefore, more to learn and benefit from a knowledge of the nature of the soil, as we are but beginning to feel the necessity of more intelligent methods, of more intensive agriculture. If our nation can in the present century do what Kellermann asserts the German nation did in the past century, increase the productive capacity of the soils 2½ times, it will be a notable achievement and one well worth the effort. There seems to be no reason why this can not be done. It must be a national effort participated in by all the people, as upon it depends the very foundation of the continued prosperity and integrity of the nation.

THE FUNCTION OF THE SOIL AS A MEDIUM FOR PLANT GROWTH.

The soil is essentially a mixture of a large variety of mineral fragments. Nearly all agricultural lands contain most of the common rock-forming minerals and these minerals contain the mineral plant food elements. These minerals are slightly soluble in water, sufficiently soluble to maintain a solution of about 25 parts per million of potassium and about 8 parts per million of phosphoric acid. This strength of solution is amply sufficient for plants to draw their nourishment from, provided the supply is maintained as the plant withdraws sufficient for its needs. This constant supply is assured by the rapidity with which minerals dissolve—a saturated, although a very dilute solution being obtained after a few minutes contact of the soil and water. The supply, or rather the concentration, is maintained nearly constant by the additional wonderful power the soil has of absorbing mineral matter and the large variety of mineral species, so that the composition and concentration of the soil moisture does not vary greatly for light sands, loams, or heavy clays, nor for what we recognize as productive and unproductive soils.

In 1903 the Bureau of Soils, by very delicate methods, made a large number of analyses of the water-soluble material in fields of growing crops in both good and poor condition to see if any evidence could be found of any temporary exhaustion due to the absorption of mineral matter by the crops more rapidly than the rate of solution, and to ascertain also if constant differences were shown between the productive soils and soils of low productivity. The results, published in Bulletin 22 of this bureau, are restated in Appendix C of this report.

It will be remembered that while the methods of analyses are accurate to within 1 or 2 parts per million, and in the case of potash especially much more accurate than this, on different portions of the same extract of the soil there is sufficient variation in the soil of a field to account for many of the differences shown, especially where the variations appear to be erratic and uneven.

It seems evident from these results and other investigations of the bureau that there is no significant difference in the composition of the soil moisture in good and poor soils, and not even a significant temporary exhaustion of the average soluble mineral content of the soil during the crop season with the crop actually growing in the field. Moreover, the soluble mineral content has generally been found to be as high as or higher in the soil than in the subsoil. Summing up the results of modern investigations, it may be said that soil will not, in general, be worn out or exhausted so far as mineral plant food elements are concerned until most of the minerals of the soils have been dissolved and carried away, which is not conceivable in finite time under natural conditions. It is a fact recognized since the earliest historic times, referred to by many of the old Latin writers and familiar to us all in this country at the present time, that soils differ greatly in productivity and that the productivity of any particular farm or field may decline very markedly and very rapidly. It is no uncommon experience to see a farm, which has been well tilled and kept up to a high state of productivity for many years, rapidly decline when turned over to tenant farmers. Such changes attract the eye in the marked comparison with neighboring crops, dilapidated farm buildings, and general discontent of the less successful man. When the converse of this occurs and these lands are taken up and improved, these differences disappear and the change is less likely to be noted, or, if noted, soon forgotten. It is the same with sickness or disaster to the individual or to the community or to the nation, the years of even success fail to impress the mind as do the seasons of losses and troubles, so that it will come to many as a matter of surprise that on the whole our soils are more productive and that the available plant food supply shows no sign of wearing out. We have, however, a duty to the individual as well as to the nation, especially as in this case where a slight turn from failure to success of many individuals will elevate the nation in its commercial position in the world, so it behooves us to see why it is that many individuals fail to secure from the soil adequate returns, as measured by the returns secured by many other individuals on similar soils, and then to see why one part of our nation secures larger returns of necessary crops than other portions, and to learn if these matters may be equalized.

It is recognized throughout the civilized world that it is better to depend upon proper sanitary conditions to prevent and even to cure most diseases than upon drugs. It is recognized by animal breeders and animal users that sanitation is of the utmost importance; we recognize that fish in our aquarium, that yeast for commercial industries, that bacteria propagated for useful as well as for scientific purposes can only be kept alive and in condition if the products of their own life processes be removed or neutralized from time to time. Our plants are living organisms fixed in position in the soil during life, and like all other living organisms break down as well as build up organic bodies and give off or leave waste products in the soil. Such products appear to be generally harmful to the same species of plant following immediately after a first crop has been removed.

Moreover, this waste matter is further changed by soil organisms, direct oxidation processes, or by plant roots themselves into other degradation products, and finally in our best soils into the material generally harmless to plants which we recognize under the general term of humus. This is probably the complete and ideal form of soil sanitation, but it appears that this change does not proceed normally along such ideal lines in all soils or so as to leave them in their best condition for following crops, and as cultivation and cropping have much to do with these soil changes we are liable, through ill-adapted methods of management, to make matters worse instead of better as time goes on. Intermediate products of plant metabolism are left in the soil in forms, other than humus bodies, which are toxic to plants. Some such organic bodies have been separated from soils by this bureau and found to be toxic to some plants and non-toxic or even stimulating to other plants. Organic bodies of known composition, separated from wheat-sick soils and originated in the soil during the growth of successive crops of wheat, are toxic to wheat plants but not so to cowpeas. Similarly, organic bodies from cowpea-sick soils and formed in the soil during the growth of successive crops of cowpeas are toxic to cowpeas but not so to wheat. After cowpeas have been grown on the wheat-sick soils these bodies, associated with the unfavorable conditions for wheat, are found to have disappeared in whole or in part, and following the cowpeas wheat can again be produced, and so with other crops. Thus we have a logical and demonstrable reason for crop rotation.

Furthermore, lime, nitrate of soda, and certain organic matters such as the green parts of fresh cowpeas, stable manure, and in general organic matters rich in protein material, in decomposing in the soil react on certain of these toxic bodies and change or destroy them, thus improving the soil for subsequent crops. Potash and phosphoric acid appear to act with similar effect, although the action is less well understood. We have here probably one of the principal reasons, and a demonstrable one, for the action of fertilizers and manures in improving the sanitary conditions of the soil.

With this brief statement of the function of the soil as a medium of plant growth, we will turn now to the consideration of the differences in yields of any particular crop on different soils and in various sections of the United States. In the humid portion of the eastern United States, with the same kind of soil material, differing only in texture and water content, the distribution of profitable crops is largely determined by the texture of the soil. On the light sandy members of the series we have conditions favorable to certain fruits and early truck crops. As the texture becomes heavier we find conditions more favorable successively to corn, wheat, and hay grasses. This distribution is typically shown, for example, on the limestone soils of the valley of Virginia. In the Middle West, with a smaller rainfall, we find our best corn soils heavier than the best wheat lands. On the Pacific coast, and in general in the arid and semiarid portion of the country, with and without irrigation, this influence of texture largely disappears.

It appears that this influence of texture is not due to a mere difference in the supply of moisture maintained for the crop, but is due to chemical processes of reduction of the excreta and the remains of plants, which processes are affected both by the amount of moisture in the soil and the temperature.

While it is permissible to judge of the increase or decrease of soil fertility from long-time records of the yield per acre of any crop on the same field or of the same State when the acreage has remained fairly constant, as has been done in the first part of this report, it is not fair to assume that the average yield of about 16 bushels of wheat in New York and about 7 bushels in North Carolina, South Carolina, Georgia, and Alabama, or of about 30 bushels of corn in New York, and 11 or 12 bushels in the latter States, shows that the fertility of the New York soils in general is higher than the fertility of the other States, for, measured in other crops, the reverse might be shown. The figures do show, however, that so far as grain production is concerned the soil conditions in New York are more favorable than those of the South. This does not appear to be so much the effect of climate on the plant as of the plant's effect on the soil, as may be shown in a variety of ways. The same difference in yield of the cereal crops is shown in the countries of the north and south of Europe as in our own northern and southern States.

The largest yield of corn per acre on record (209 bushels) was on a trial acre in South Carolina, where the average yield is but 9.7 bushels, and very large yields are reported where a new method of culture is being tried of checking the vegetative growth with the toxic effect of weeds in their early stages of growth, followed by thorough cultivation and judicious fertilization.

The subsoil is generally toxic to crops in the humid southern States, but is as a rule equally as productive as the top soil under the arid climate of the West. There is every reason to believe that other varieties of our grain crops may be originated through selection which will be better adapted to southern soil conditions than those we now have, or that methods of culture may be devised which will permit of a much larger yield of grain in the Southern States than we now obtain.

One of the most interesting cases which appears to show the influence of the climate on the soil as a medium of plant growth is the case of the alfalfa crop. Adapted to almost all types of soil west of the Mississippi River under moisture conditions suitable to other crops, it has almost universally failed in the soils of the humid Eastern and Southern States, with two notable exceptions. One of these is the Dunkirk stony loam of New York, and the other the Houston clay extending from Alabama to Texas. The failure in the East is not due to lack of plant food. Inoculating the soil with the specific alfalfa bacteria does not insure success, nor can failure be attributed to the influence of climate on the crop, as there is no greater range of climate in the East than in northern New York and southern Alabama where the plant grows successfully on two different types of soil.

The following interesting article appeared in a recent number of "The Southern Planter:"

> Alfalfa is undoubtedly a splendid forage plant where it will thrive without undue attention from man; it may be said to be the backbone of far western agriculture; but, like many other promising field crops, it should be studied with reference to soil and locality before extensive planting. A great many eastern farmers have failed ignominiously with alfalfa, and on a large scale, when a little less enthusiasm and a little more careful testing would have been the part of wisdom.

"West of the one hundredth meridian," said Professor Spillman, the agriculturist in charge of Farm Management, of the Department of Agriculture, in answer to the inquiry as to the department's present knowledge of alfalfa, "character of soil is but little considered in growing alfalfa; it will thrive anywhere that there is water. East of that line the plant is very discriminating as to its food. Wide experiments have been made by the various experiment stations and the Department of Agriculture all over the East, and in only a few circumscribed localities does it 'grow as a weed.' In some sections of the South, in a small limestone region of New York and southern Vermont, and in a few other scattered localities it grows readily, while it also does very well in parts of Wisconsin, Minnesota, and Illinois. But thousands of alfalfa fields in all the Eastern States have failed, and, while it is now known that alfalfa can be grown on these fields, the cost is, in the majority of soils, prohibitive.

"* * * It should not be expected that in the East the plant will endure and thrive twenty or thirty years as it does in the West," continued Professor Spillman. "If it would, the first cost of securing a good stand, however great, would be an inconsiderable quantity; but even where a good stand is secured the usual life of the field is, on lighter soils, one or two years, ranging up to five years on heavy, rich soils, with as high as three cuts per year, except in the specially adapted localities above mentionel."

It is an interesting fact developed by the Soil Survey that two soil types extending through different climatic regions best adapted respectively to corn and wheat in one locality will show the reverse adaptation under different climatic conditions. In the progress of the Soil Survey, the bureau has mapped 122 types of loam soils in the United States. About 58 per cent of the total acreage of these soils should be given first rank in the production of some one or more of our staple crops, about 26 per cent medium rank, and about 16 per cent low rank. They all have approximately the same texture, although they differ in the character of the soil material, mode of formation or deposition, and may differ in structure. They certainly differ in their relation to crops, or require different methods of management to produce crops. So far as investigations have gone, they all would seem to have an adequate supply of mineral plant food elements in the soil moisture, yet they appear to have dissimilar chemical powers, especially as regards the reduction of organic bodies, and the products of the same. Considerable progress has been made in selecting new crops and special varieties of crops for some of these soils, and important special industries are already established on soils which a few years ago had low agricultural rank. There seems to be great possibility in this direction in the future.

METHODS OF CONTROL.

Certain plants adapt themselves to certain soil conditions and grow for long periods in an undisturbed soil. This is true generally of forest growths and of most native vegetation. The buffalo grass is fast disappearing with the advent of the plow. The huckleberry bush has not been successfully cultivated until recently, when done through root fungi. Many plants do well in association with certain other plants and will not grow at all in other associations. Practically all of our annual crops, however, require cultivation always before and many of them during most of their periods of growth. This cultivation loosens the soil and puts it in better physical condition for the crop to start in, tends to conserve the moisture, and to keep out weeds, which are generally undesirable by reason of the toxic action of the organic matter thrown off by their roots. But cultivation does more than this. Plowing is essentially a method of fermentation, or, rather, a method to regulate fermentation in the soil; as aromatic principles are developed in certain tobaccos by properly regulating the supply of air by occasionally opening the bulk, so the soil is relieved of many objectionable organic bodies by proper cultivation and the judicious introduction of air. The color of an infertile soil or a raw unproductive subsoil recently turned up to the surface will gradually change and generally darkens with thorough cultivation, and the change in color will indicate to an experienced eye the progress toward more productive conditions.

This is the oldest as it is still the most fundamental method of control of soil fertility. It is a method, furthermore, which requires a high degree of judgment and of skill. Each class of soil requires its own peculiar method, and each change of climatic condition must be considered.

It is often as injurious to plow too much as to plow too little. The time, manner, and condition of the soil are all important factors in regulating cultivation for the maintenance or improvement of fertility. The American farmer has much to learn regarding the best method for the mere handling of his soil. Much of this must come from hard actual experience on the same type of soil for a period of years, but much help may be rendered him through the elucidation of the many at present obscure changes involved in the proper sanitation of the soil.

The second method of controlling the fertility of the soil, and one almost as old as cultivation, is the proper rotation of crops, the importance of which was recognized by the old Latin writers, and clearly recognized by the early English writers.[a]

As soon as we remove the native vegetation which has become adjusted to the soil and introduce new crops forced under cultivation to produce the largest possible yield, the capacity of the soil to reduce

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[a] According to A. B. Griffith, the earliest English work of importance on agriculture was "Ye Boke of Husbandrie," by Sir Anthony Fizherbert, published in 1534. Twenty-eight years after the publication of Fitzherbert's work, Martin Tusser published his famous "Five Hundred Points of Husbandrie" in which he strongly recommends the rotation of crops, thus:

"Otes, rie or else barlie, and wheat that is gray,
Brings land out of comfort, and soon to decay;
One after another, no comfort betweene
Is crop upon crop, as will quickly be seene,
Still crop upon crop many farmers do take,
And reape little profit for greedinesse sake."

A Treatise on Manure, 3rd edition, page 3 (1903).

With all the development of modern agriculture in the taking up of new lands and the enormous increase in the aggregate crop production of the world, it seems apparent from the old writers that agriculture as an art has declined.

According to Dickson, the Romans had a greater variety of crops and exercised considerable more care in adapting them to the different soils than did the English at the time he wrote (1788) or more than we seem to give in this country. Considering Pliny as more particular in his directions as to the adaptation of crops to soil, Dickson gives Pliny's maxims in detail as follows:

"'Such a difference of soil,' as Pliny says, 'points out the necessity of describing the kinds proper for the different crops. This is Cato's opinion, that corn should be sowen on land that is stiff, rich, and in good heart; that raddish, the organic excreta and maintain proper sanitary conditions is often taxed beyond its power to maintain the yield, especially if the same crop is grown year after year. When the crop is changed, a certain crop appearing only once in three or four years, the soil has a longer time to dispose of the waste products. There are, however, two other principles underlying the practice of rotation which, if intelligently used, make it a highly efficient method of control of soil fertility. Some plants are quite indifferent to and are even stimulated or at least benefited by the excreta of other plants, and in thus benefiting they aid in destroying the toxic organic bodies and in purifying the soil.

By growing successive crops of cowpeas or of wheat in small volumes of soil, the bureau has succeeded in making this soil sick for either crop respectively. Pure organic bodies have been isolated from both the soils which are toxic to the plants producing them, but beneficial to the plant which has not caused their accumulation. When wheat is produced on the cowpea soil, therefore, it usually grows better, and after the wheat, cowpeas will grow again better than before. This, in brief, is the principle of rotation modified in details by the nature and previous cropping of the soil and by climatic conditions. The application of empirical rules brought down to us through long experience is very beneficial in maintaining fertility, but much may be expected from the investigation now going on, which will make the practice more effective and more reliable.

The third method of control, namely, the use of manures and commercial fertilizers, has likewise long been practiced, but within recent years the use of commercial fertilizers has grown to enormous proportions in some sections of the country, although used very little or not at all in other sections. The present practice of fertilization is based upon the fallacious doctrine that the soils become exhausted of plant food through continuous cropping and gradually become worn out. If this were so it would have the population of the world eventually dependent upon a few comparatively small deposits of nitrates,

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millett, and panic, should be sowen upon the same kind of land, if moist or wet; that seed should be first sowen in cold and wet, soils, and afterwards in warm; that lupines should be sowen in the red soil, the soil called pulla or sandy soil, if they are not wet; *far* in moisture fields, where the soil is chalky and red; *triticum* [wheat] in dry land, not liable to weeds, nor in a shade; beans in strong soils; *filigo* and *triticum* in open and exposed fields, that receive greatest benefit from the heat of the sun; lentils in uncultivated and red soil where there is not much grass; barley on fallow, and land so rich as to carry a crop every year. Spring sowing should be used in places that cannot conveniently be sowen in autumn, and in soils whose fatness can carry constant crops: This maxim too is exact. These things should be sowen in shallow soil, that do not require much sap, as the *cytifus* and *cicer;* legums are excepted, which are pulled up and not cut in reaping; hence they are called legums, because thus gathered. In fat soil should be sowen such things as require much food, as garden erbs, *triticum*, *filigo*, flax. So for the same reason, the shallow soil is allotted for barley, because it does not require much food, the richer and stiffer for triticum. In low lying grounds, *far*, rather than *triticum*, should be sowen. In grounds neither very high or low, both *triticum* and barley; hilly ground produces plumper triticum, but not so large a crop: Far and filigo may be appointed to chalky and wet soils.' "

Theophrastus does not enter into particulars, as the Roman authors do, but he declares, in general, that to know how to adapt plants to soils is one of the principal things in agriculture.

The Husbandry of the Ancients; Adam Dickson, Edenburg, 1788; page 187.

phosphates, and potash, and the regulation and conservation of these deposits would be of far more importance than of the coal and iron supply. But we have seen from the statistics given that the soils of the world are not wearing out, but, on the whole, are becoming more productive, and that even the more unproductive soils have ample supplies of mineral plant-food constituents in their soil moisture for better crops than they produce.

While plants may, and undoubtedly do, avail themselves of the mineral plant food elements of the manures and fertilizers, it appears from modern investigations, and is entirely in harmony with experience, that this is not the only benefit derived from their application. Toxic organic bodies which the soil finds difficult to reduce are frequently much more quickly and effectively reduced in the presence of an easily decomposible substance, like fresh cowpea vines or properly fermented manure, while nitrates and other mineral salts help to oxidize or otherwise change to harmless forms the toxic material, thus assisting in the proper sanitation of the soil. Furthermore, certain plants and fertilizers together are much more effective in destroying these toxic bodies than either alone, so that in the rotation for any particular soil there is an order in which the plants should succeed each other, and also when manures and fertilizers are used a most efficient place in the rotation when these should be used, as has already been determined empirically from experience. The effect of cultivation, crop rotation, and fertilizers in improving the physical condition of the soil need not be dwelt upon here.

CONCLUSION.

The fertility of the soil is a great national asset which can not be exhausted. It is not being developed or availed of in all cases as it should be, and will not be until, through investigation, we know more of the peculiarities of certain of our soils, their adaptation to crops, and special methods of control. The soils in different sections of the country are unequally adapted to certain of our staple crops, which permits of specialization, or this difference can undoubtedly be largely minimized through new and improved methods of control if desirable.

In all sections, as in all business and professional work, we have individual cases of failure and success, the cases of failure being generally due to inefficient methods and lack of knowledge, which can be overcome only by better training and education. On the whole, the management of the soils of the world seems to be improving, at least in modern times. This improvement appears to have been greater in Europe, where the population has been denser and the need more pressing than in our own country.

The time has now arrived, when practically all available new lands in this country have been taken up, when improvement must be more rapid than in the past to maintain the integrity of the nation and its commercial supremacy among the nations of the world, and this can best be done by continuing and extending the educational work and the investigations along broad national lines which the administration and the Congress have supported in the past.

APPENDIX A.

Acreage and yield per acre of cereal crops in European countries.

AUSTRIA.

Year.	Wheat.		Rye.		Oats.		Barley.		Corn.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*
1884...	2,735,600	15.5	4,896,900	15.1	4,532,900	26.4	2,655,000	19.8	805,300	18.3
1885...	2,950,600	16.0	4,928,400	15.7	4,519,600	22.9	2,882,300	18.4	908,500	22.2
1886...	2,900,800	15.0	4,970,100	14.9	4,616,300	27.3	2,762,600	19.9	895,900	21.5
1887...	2,876,500	18.0	4,969,700	18.0	4,632,600	25.1	2,798,900	21.7	892,000	18.2
1888...	2,930,000	17.4	4,979,200	16.1	4,630,900	25.1	2,795,800	21.5	897,300	18.6
1889...	2,704,400	13.9	4,876,000	14.2	4,639,300	18.9	2,812,800	16.9	943,700	17.8
1890...	2,835,000	15.1	4,941,000	16.0	4,630,100	24.9	2,757,600	20.6	919,000	21.4
1891...	2,747,900	14.4	4,794,800	14.0	4,679,300	25.7	2,815,800	20.2	923,200	21.2
1892...	2,780,400	17.8	4,865,800	17.0	4,628,700	26.9	2,747,000	23.6	907,800	21.8
1893...	2,766,500	15.4	4,800,800	15.9	4,551,600	21.0	2,777,400	19.4	886,400	17.8
1894...	2,713,000	17.4	4,822,000	17.2	4,643,400	26.0	2,806,900	22.3	806,000	17.0
1895...	2,628,600	15.3	4,477,200	14.5	4,817,600	26.1	2,949,500	20.9	859,400	21.9
1896...	2,615,800	16.0	4,537,800	16.3	4,737,500	23.3	2,911,200	19.4	854,600	20.7
1897...	2,615,100	13.2	4,543,600	13.9	4,724,100	21.5	2,899,200	17.6	829,700	16.0
1898...	2,609,300	18.0	4,513,600	17.7	4,697,900	27.4	2,886,000	22.0	841,500	19.5
1899...	2,649,200	19.0	4,549,800	18.7	4,613,800	30.2	2,939,100	24.9	825,200	17.5
1900...	2,632,400	15.5	4,206,000	13.0	4,692,100	25.2	3,049,500	20.2	827,800	18.7
1901...	2,643,400	16.7	4,474,400	16.9	4,622,400	25.6	2,991,900	22.4	820,700	21.4
1902...	2,614,100	19.0	4,527,300	18.2	4,528,000	27.7	3,005,000	24.6	819,200	16.4
1903...	2,600,600	17.8	4,465,600	18.2	4,530,500	28.3	2,977,600	24.8	824,200	19.5
1904...	2,754,900	19.5	4,760,200	19.3	4,501,500	24.3	2,926,300	22.8	836,200	15.0
1905...	2,782,300	19.6	4,864,600	20.2	4,467,600	27.7	2,935,900	24.0	861,100	20.1
1906...	2,880,400	20.2	4,997,200	19.9	4,529,200	34.1	2,909,900	26.1	836,200	20.7

HUNGARY.

Year.	Wheat.		Rye.		Oats.		Barley.		Corn.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*a	*Acres.*	*Bush.*a	*Acres.*	*Bush.*a	*Acres.*	*Bush.*a	*Acres.*	*Bush.*a
1883...	6,438,300	14.1	2,714,900	14.8	2,453,000	20.9	2,402,600	16.4	4,507,500	19.4
1884...	6,797,800	15.8	2,729,400	15.7	2,457,800	23.2	2,450,000	19.0	4,585,300	19.7
1885...	7,172,100	16.6	3,061,200	14.7	2,841,600	20.9	2,757,100	20.6	5,396,000	22.3
1886...	7,229,800	15.0	3,048,900	13.4	2,878,400	20.8	2,751,100	14.7	5,502,400	17.7
1887...	7,275,200	20.8	3,035,300	17.9	2,857,400	23.0	2,650,100	21.9	5,291,000	15.9
1888...	7,277,500	19.5	2,992,000	15.1	2,846,300	21.2	2,590,100	18.3	5,398,900	20.1
1889...	7,636,800	12.9	2,931,900	13.5	2,757,000	16.7	2,645,800	13.7	5,585,600	20.5
1890...	7,824,300	19.8	2,942,600	18.1	2,692,600	21.1	2,654,200	20.8	5,589,000	18.4
1891...	7,929,700	18.4	2,798,500	14.1	2,722,300	25.2	2,739,300	20.8	5,830,000	27.7
1892...	8,035,800	18.5	2,973,800	16.5	2,714,700	24.3	2,743,500	19.7	6,031,000	21.9
1893...	8,048,500	19.5	3,209,400	17.9	2,625,400	29.2	2,749,000	24.4	5,941,500	25.8
1894...	8,483,900	18.2	2,991,900	19.5	2,664,600	30.1	2,7[illegible]0,600	22.7	5,898,000	14.0
1895...	8,304,800	20.7	2,802,800	16.7	2,593,600	29.6	2,658,400	21.4	6,208,300	26.5
1896...	8,311,200	19.4	2,807,200	18.2	2,546,700	31.4	2,666,200	24.0	6,049,200	24.7
1897...	7,444,800	11.7	2,691,300	13.5	2,450,400	24.3	2,507,300	17.6	5,793,100	20.5
1898...	8,160,100	17.1	2,735,400	16.9	2,587,300	33.1	2,583,600	23.6	6,191,900	23.9
1899...	8,438,000	17.8	2,816,400	17.7	2,625,900	33.3	2,681,400	24.0	6,169,300	21.2
1900...	8,807,000	17.3	2,782,100	15.4	2,672,700	28.5	2,667,700	21.3	6,396,100	22.9
1901...	8,866,300	15.2	2,795,000	15.6	2,674,300	27.6	2,680,500	19.8	6,392,200	22.1
1902...	8,950,300	20.4	2,808,700	18.7	2,679,400	33.3	2,695,700	24.3	6,287,800	19.1
1903...	9,227,000	19.1	2,801,700	18.1	2,776,500	34.1	2,746,800	24.9	6,579,000	24.2
1904...	9,131,300	16.1	2,700,400	16.6	2,703,700	25.0	2,693,800	19.4	5,828,600	12.1
1905...	9,197,700	18.5	2,790,900	19.0	2,759,300	30.5	2,722,400	24.0	6,235,400	18.0
1906...	9,526,600	21.8	2,802,400	19.4	2,815,700	23.4	2,769,800	26.3	6,731,800	26.0

a Prior to 1893 Winchester bushels.

Acreage and yield per acre of cereal crops in European countries—Continued.

BELGIUM.

Year.	Wheat.			Rye.		Oats.		Barley.		
	Area.	Average yield.		Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	
		Winter.	Spring.						Winter.	Spring.
	Acres.	*Bush.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Bush.*
1880	681,800	26.6	23.7	686,100	26.5	616,500	48.6	99,300	36.0	31.4
1881	666,000	23.4	19.5	687,000	20.9	616,000	38.7	99,300	35.4	27.9
1882	650,000	25.7	19.9	688,000	26.0	616,000	44.5	99,300	38.6	29.1
1883	635,000	25.0	22.1	689,000	23.9	616,000	41.1	99,300	37.6	31.1
1884	619,000	25.9	22.0	690,000	26.4	616,000	45.4	99,300	42.3	33.8
1885	603,000	27.5	22.7	691,000	26.1	616,000	46.4	99,300	42.7	32.1
1886	587,000	27.0	22.9	692,000	22.4	616,000	52.4	99,400	39.3	35.8
1887	572,000	29.8	....	693,000	27.7	616,000	42.0	99,400	43.9	32.0
1888	556,000	21.9	10.3	694,000	21.7	615,000	50.1	99,400	35.1	32.8
1889	540,000	28.2	21.8	695,000	26.6	615,000	49.2	99,400	40.4	32.9
1890	524,000	28.6	23.2	696,000	28.7	615,000	55.2	99,400	45.4	34.5
1891	509,000	23.0	26.0	696,000	22.4	615,000	59.3	99,400	34.3	38.3
1892	493,000	31.2	25.9	697,000	33.3	615,000	49.2	99,400	44.9	36.9
1893	477,000	27.7	22.7	698,000	28.0	615,000	35.1	99,400	38.8	29.4
1894	461,000	28.4	22.5	699,000	30.5	615,000	50.6	99,400	40.6	32.0
1895	445,700	28.8	25.5	700,200	30.4	614,500	55.8	99,400	43.6	32.0
1896	440,000	30.7	23.7	681,000	32.3	617,000	46.4	99,000	44.6	33.5
1897	434,000	26.9	24.0	662,000	29.5	619,000	54.9	98,000	37.3	31.1
1898	429,000	31.7	22.8	644,000	29.6	621,000	66.8	97,000	42.2	33.9
1899	423,000	26.2	20.4	625,000	26.5	624,000	53.3	96,000	42.3	39.8
1900	417,500	33.0		605,800	32.8	625,800	62.6	96,000	50.1	
1901	419,700	34.5		620,400	34.1	615,800	65.9	94,600	51.3	
1902	415,700	34.9		654,900	34.2	646,200	70.5	93,900	52.9	
1903	355,400	34.7		626,800	34.7	705,800	68.5	79,800	49.2	
1904	393,200	35.1		639,300	34.4	613,300	61.1	98,800	50.7	
1905	402,500	30.8		659,700	32.4	586,500	57.6	94,400	47.9	

DENMARK.

Year.	Wheat.		Rye.		Oats.		Barley.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]
1883	132,900	33.9	670,700	26.4	1,010,500	30.2	769,800	27.1
1884	130,300	36.0	675,400	24.7	1,019,900	30.4	763,100	27.2
1885	127,700	40.1	680,000	26.3	1,027,400	33.1	756,400	27.6
1886	125,100	37.7	684,700	24.2	1,035,800	34.1	749,800	31.0
1887	122,500	43.7	689,300	25.0	1,044,300	30.5	743,100	29.4
1888	119,900	27.4	694,000	23.6	1,052,700	33.7	736,400	30.1
1889	115,600	36.3	697,000	26.0	1,056,900	26.5	730,800	25.5
1890	111,200	33.9	700,100	24.3	1,061,000	35.2	725,100	32.3
1891	106,800	39.1	703,100	27.8	1,065,200	32.3	719,500	31.5
1892	102,500	41.6	706,100	28.9	1,069,300	38.1	713,800	34.6
1893	98,100	39.3	709,100	27.7	1,073,500	25.9	708,200	24.4
1894	93,700	34.8	712,200	23.4	1,077,600	35.6	702,500	30.3
1895	89,400	38.8	715,200	25.7	1,081,700	37.2	696,900	31.3
1896	85,000	43.4	718,200	28.0	1,085,900	35.5	691,200	30.7
1897	....	40.9	....	25.2	....	32.4	....	27.7
1898	....	35.2	....	22.5	....	38.2	....	31.6
1899	....	43.0	....	25.6	....	34.1	....	31.4
1900	....	42.4	....	27.8	....	37.1	....	33.0
1901	32,200	29.2	673,400	24.7	1,069,100	35.0	695,300	32.0
1902	[b]101,200	44.7	[b]674,300	27.9	[b]1,057,100	38.6	[b]656,600	35.5
1903		44.1		28.6		39.0		35.5
1904		42.5		24.5		36.1		34.6
1905		40.2		28.5		30.9		32.2

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[a] Winchester bushels.

[b] Area returned by the census of 1901 as intended for the crop named at the time of fall planting; the area actually harvested in 1901, owing to the failure of the wheat crop, differed considerably from these figures.

Acreage and yield per acre of cereal crops in European countries—Continued.

FRANCE.

Year.	Wheat.		Rye.		Oats.		Barley.		Corn.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*
1883	16,812,500	17.3	4,249,400	16.4	9,215,700	32.9	2,633,000	22.5	1,556,500	17.7
1884	17,426,300	18.6	4,263,800	17.3	9,135,700	31.2	2,613,100	21.7	1,523,800	18.4
1885	17,190,400	18.2	4,133,900	16.6	9,117,200	30.7	2,361,400	21.7	1,386,000	18.4
1886	17,189,000	17.6	4,038,400	15.8	9,232,000	31.5	2,339,300	22.6	1,357,400	18.7
1887	17,216,900	18.6	4,013,700	16.6	9,192,600	28.2	2,309,000	21.7	1,379,600	21.6
1888	17,243,200	16.0	4,024,900	15.5	9,227,500	29.3	2,208,400	20.8	1,412,100	20.0
1889	17,393,600	17.6	3,962,400	16.5	9,287,500	29.6	2,158,500	21.2	1,379,700	18.9
1890	17,449,800	19.0	3,925,600	17.4	9,342,300	32.6	2,168,400	23.0	1,350,700	17.4
1891	14,220,400	15.2	3,703,000	16.4	10,483,900	32.6	3,022,500	24.7	1,377,900	19.4
1892	17,264,200	18.0	3,809,900	17.6	9,421,700	28.5	2,263,700	21.2	1,381,100	19.5
1893	17,477,800	15.9	3,781,000	17.0	9,495,000	20.7	2,161,300	16.6	1,402,200	18.8
1894	17,276,200	19.9	3,844,300	19.5	9,591,100	30.7	2,200,000	22.6	1,428,900	19.4
1895	17,301,400	19.6	3,789,400	19.0	9,807,400	31.2	2,200,900	22.6	1,444,400	18.3
1896	16,976,900	20.0	3,707,100	18.8	9,677,300	30.6	2,110,000	22.5	1,442,400	21.2
1897	16,268,800	14.9	3,587,300	13.3	9,860,800	25.7	2,119,900	19.6	1,445,500	21.2
1898	17,207,600	21.2	3,644,600	18.4	9,606,200	33.5	2,012,600	24.1	1,388,000	17.2
1899	17,149,500	21.3	3,679,100	18.3	9,734,200	31.6	1,992,300	23.7	1,386,400	18.5
1900	16,961,400	19.2	3,508,300	16.9	9,739,400	29.3	1,871,100	22.6	1,337,300	16.8
1901	16,787,700	18.5	3,489,400	16.7	9,601,700	26.5	1,838,700	21.8	1,351,900	19.9
1902	16,219,200	20.2	3,290,800	13.9	9,469,400	33.8	1,714,700	25.4	1,242,000	20.3
1903	16,009,200	22.7	3,205,500	18.1	9,498,100	26.3	1,722,500	26.2	1,239,500	20.8
1904	16,133,200	18.6	3,144,300	16.8	9,475,500	30.7	1,741,300	22.6	1,224,600	16.2
1905	16,085,800	20.8	3,136,900	18.7	9,420,100	32.5	1,746,200	24.1	1,241,400	19.6
1906	16,103,200	20.4	3,095,100	16.4	9,525,600	31.0	1,752,800	21.6	....	......

GERMANY.

Year.	Wheat.		Rye.		Oats.		Barley.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*
1883	4,760,300	18.2	14,399,000	15.4	9,323,700	27.6	4,326,500	22.7
1884	4,755,400	19.2	14,447,200	14.9	9,336,400	31.4	4,287,900	23.9
1885	4,742,600	20.2	14,435,500	15.9	9,357,400	32.1	4,305,500	24.2
1886	4,736,100	20.7	14,428,200	16.6	9,406,100	35.6	4,278,600	25.1
1887	4,743,600	21.9	14,436,500	17.4	9,415,300	31.5	4,277,700	23.7
1888	4,777,300	19.5	14,367,300	15.1	9,470,200	33.8	4,257,900	24.4
1889	4,834,400	18.0	14,336,700	14.7	9,604,000	30.1	4,163,700	21.4
1890	4,843,700	21.5	14,382,200	16.1	9,647,000	35.1	4,112,300	25.5
1891	4,658,700	18.4	13,540,500	13.9	10,266,400	35.4	4,464,400	25.9
1892	4,881,900	23.8	14,032,300	19.2	9,853,800	33.2	4,176,300	26.6
1893	5,051,100	24.8	14,856,600	23.7	9,654,300	29.8	4,020,500	27.7
1894	4,893,900	25.0	14,936,400	22.0	9,678,400	46.8	4,023,000	33.1
1895	4,771,200	24.4	14,563,300	20.9	9,955,100	43.2	4,177,500	31.3
1896	4,761,400	26.4	14,782,200	22.7	9,833,900	41.8	4,142,300	30.8
1897	4,746,000	25.3	14,744,100	21.8	9,881,800	39.9	4,116,800	29.1
1898	4,866,200	27.2	14,690,800	24.2	9,875,600	47.1	4,102,200	32.2
1899	4,982,800	28.4	14,507,600	23.5	9,883,500	48.0	(a)	(a)
1900	5,063,500	27.9	14,715,000	22.9	10,187,600	48.0	(a)	(a)
1901	3,907,800	23.5	14,362,100	22.4	10,900,800	44.6	(a)	(a)
1902	4,725,200	30.3	15,208,100	24.6	10,270,400	50.1	(a)	(a)
1903	4,466,300	29.2	14,857,900	26.2	10,601,700	51.2	(a)	(a)
1904	4,738,300	29.5	15,071,500	26.3	10,352,900	46.2	(a)	(a)
1905	4,762,000	28.5	15,186,000	24.9	10,334,000	43.6	(a)	(a)
1906	4,783,900	30.3	15,077,200	25.1	10,431,600	55.7	(a)	(a)

[a] Not estimated officially.

Acreage and yield per acre of cereal crops in European countries—Continued.

ITALY.

Year.	Wheat.		Rye.		Oats.		Barley.		Corn.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]
1883[b]	10,956,600	12.1	395,400	13.2	1,079,900	17.0	835,200	13.1	4,675,200	18.0
1884	....	....	....	....	....	....	....	....	....	....
1885	....	....	....	....	....	....	....	....	....	....
1886	....	....	....	....	....	....	....	....	....	....
1887	....	....	....	....	....	....	....	....	....	....
1888	....	....	....	....	....	....	....	....	....	....
1889	....	....	....	....	....	....	....	....	....	....
1890	10,889,900	12.1	348,400	12.7	1,119,400	17.0	820,400	13.4	4,724,600	15.9
1891	11,124,600	12.7	350,900	13.1	1,107,000	18.0	761,100	12.7	4,709,800	15.4
1892	11,193,800	10.3	355,800	11.9	1,112,000	15.5	773,400	10.3	4,702,400	15.3
1893	11,258,100	12.0	358,300	12.6	1,131,700	16.1	798,100	9.9	4,744,400	17.4
1894	11,302,500	10.8	350,900	12.3	1,151,500	14.8	748,700	11.1	4,697,400	12.7
1895	11,349,500	10.4	338,600	11.8	1,171,300	16.4	733,900	10.1	4,835,800	14.6
1896	11,319,800	12.8	....	....	....	....	761,100	13.2	4,833,400	16.5
1897	....	....	....	....	....	....	....	....	....	....
1898	....	....	....	....	....	....	....	....	....	....
1899	....	....	....	....	....	....	....	....	....	....
1900	....	....	....	....	....	....	....	....	....	....
1901	11,910,400	13.8	....	....	....	....	....	....	4,336,700	23.2
1902	11,737,400	11.6	....	....	....	....	....	....	4,200,800	16.9
1903	11,984,500	15.4	....	....	....	....	....	....	4,171,100	21.3
1904	13,336,200	12.6	....	....	....	....	....	....	4,796,800	19.5
1905	13,134,300	12.2	....	....	....	....	....	....	4,845,500	20.2

[a] Winchester bushels.

[b] Average, 1879-1883.

NETHERLANDS.

Year.	Wheat.		Rye.		Oats.		Barley.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]
1883	214,100	26.3	493,000	22.0	295,200	38.7	120,000	42.6
1884	219,300	26.9	498,500	21.3	278,300	40.5	116,400	42.0
1885	209,500	30.2	503,800	23.0	283,100	46.1	122,600	44.7
1886	199,300	26.3	503,400	21.3	300,400	48.8	110,100	42.8
1887	210,500	32.7	504,100	27.3	285,300	42.5	111,400	47.0
1888	209,200	25.1	500,200	19.7	281,900	44.5	111,100	38.3
1889	211,000	30.7	501,500	22.6	284,100	47.1	109,700	44.2
1890	209,600	25.9	503,100	22.1	284,300	46.6	104,400	39.8
1891	144,800	24.2	453,500	18.3	377,400	49.1	111,800	40.0
1892	183,400	29.3	495,800	25.1	312,400	48.0	107,700	46.3
1893	175,000	28.4	499,100	24.8	312,200	39.5	103,500	46.1
1894	159,600	26.1	514,700	23.9	327,400	46.1	94,900	38.2
1895	152,900	28.0	519,100	24.7	323,700	48.0	95,700	44.8
1896	153,900	32.8	531,100	25.6	317,400	48.3	97,200	47.0
1897	153,700	27.9	527,400	22.6	331,400	48.7	89,800	41.6
1898	180,600	29.9	530,100	25.8	314,100	52.9	87,000	43.9
1899	177,500	28.7	528,500	24.5	316,800	50.7	87,800	45.2
1900	157,800	29.6	528,900	25.8	324,700	53.3	94,400	48.5
1901	134,600	31.4	532,900	25.6	334,400	55.3	88,700	43.7
1902	152,400	33.5	539,300	25.9	339,800	56.6	90,100	51.6
1903	137,200	31.0	539,000	25.9	357,100	56.3	78,900	48.5
1904	133,600	33.1	534,000	25.3	357,700	52.0	76,300	47.2
1905	150,700	33.7	541,700	25.4	325,800	49.3	81,700	49.1

[a] Winchester bushels.

Acreage and yield per acre of cereal crops in European countries—Continued.

ROUMANIA.

Year.	Wheat.		Rye.		Oats.		Barley.		Corn.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]
1886	2,903,700	11.9	570,800	11.2	560,700	17.5	1,371,200	10.6	4,234,400	17.1
1887	2,791,500	17.0	586,600	13.0	582,200	21.2	1,504,600	12.4	4,560,600	10.7
1888	3,104,400	18.6	743,500	19.7	528,600	20.4	1,251,600	18.4	4,283,500	14.7
1889	3,310,900	15.1	424,500	13.5	483,800	13.6	1,263,900	12.5	4,435,800	15.6
1890	3,730,500	13.9	412,900	11.4	441,100	17.2	1,280,200	12.6	4,307,300	14.1
1891	3,811,600	12.7	391,200	12.9	456,900	16.9	1,299,500	17.1	4,184,200	14.3
1892	3,696,900	17.3	328,900	14.1	557,700	19.8	1,384,300	14.9	4,502,500	20.5
1893	3,221,200	18.9	353,400	21.8	622,300	24.8	1,467,600	24.4	4,544,700	16.0
1894	3,441,300	12.7	395,400	14.6	649,100	15.4	1,381,900	12.2	4,367,700	6.8
1895	3,553,400	19.3	537,600	17.2	668,500	15.5	1,365,600	16.4	4,560,300	15.6
1896	3,719,400	19.1	601,500	20.3	696,500	21.1	1,501,700	21.2	4,791,500	13.7
1897	3,941,500	9.2	582,600	11.7	712,000	13.8	1,673,400	12.7	4,583,500	17.4
1898	3,591,900	16.3	477,100	16.0	756,000	23.0	1,618,200	18.3	5,238,800	19.5
1899	4,105,300	6.3	467,900	4.2	766,500	8.2	1,578,200	2.9	4,983,600	5.6
1900	3,927,700	14.4	405,900	14.8	630,800	13.8	1,084,500	13.5	5,029,200	16.9
1901	4,044,000	17.9	522,400	18.3	655,100	25.2	1,244,700	19.5	5,258,400	22.2
1902	3,673,200	20.8	427,000	16.3	793,500	27.6	1,254,700	19.7	5,391,500	12.7
1903	3,967,600	18.6	390,500	18.3	1,054,500	29.8	1,311,900	22.7	5,120,200	15.7
1904	4,254,700	12.6	330,900	6.7	1,052,000	12.0	1,320,100	8.8	5,173,800	3.8
1905	4,838,900	21.4	398,300	33.7	921,000	20.6	1,306,600	21.9	4,882,200	12.1
1906	4,998,500	22.8	454,500	19.6	943,700	27.7	1,380,600	24.3	5,144,500	25.4

[a] Winchester bushels.

RUSSIA.

Year.	Wheat.		Rye.		Oats.		Barley.		Corn.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*
1883	28,879,300	7.9	64,604,600	8.5	34,882,800	16.5	12,441,600	10.9	1,487,800	13.1
1884		9.3		10.7		14.3		10.8		11.0
1885		6.2		10.9		11.2		8.1		11.6
1886		5.7		10.3		16.3		10.7		15.3
1887		9.7		11.5		17.7		13.5		8.7
1888	30,601,300	10.3	68,936,000	10.9	36,590,800	15.4	14,397,800	12.7	(a)	(a)
1889		6.5		8.3		14.3		8.9		
1890		6.5		9.2		15.7		11.0		
1891		5.2		6.8		12.4		9.4		
1892	32,440,700	7.1	63,200,300	8.8	34,100,200	13.7	15,485,900	10.9		
1893	32,434,000	10.9	61,961,900	11.1	33,138,000	21.2	15,787,200	18.8	2,258,000	18.0
1894	32,852,200	10.3	63,230,200	12.8	32,846,500	21.4	15,756,200	15.0	2,089,600	9.3
1895	31,894,300	9.2	62,595,300	11.5	33,973,300	19.8	15,808,600	13.3	1,917,600	13.0
1896	34,848,300	8.6	64,238,400	10.9	35,571,600	18.8	16,800,000	12.4	2,184,000	7.9
1897	35,606,400	6.7	62,646,600	9.1	36,206,500	15.1	17,218,800	11.8	2,211,500	20.6
1898	36,007,500	9.3	62,283,400	10.2	35,658,500	15.7	17,589,800	14.5	2,351,600	16.8
1899	38,045,200	8.3	63,405,600	12.7	36,112,400	23.3	17,460,300	10.3	2,406,100	9.4
1900	39,966,900	8.0	65,738,400	12.6	37,399,300	19.9	17,585,400	10.6	2,709,400	9.4
1901	41,921,000	7.6	65,950,300	10.3	37,999,800	13.9	18,128,100	10.4	2,701,100	22.5
1902	42,590,200	10.9	65,871,400	12.3	37,252,400	21.7	18,224,400	15.1	2,860,700	14.1
1903	43,753,200	10.4	66,511,200	12.1	37,590,400	17.3	19,247,000	15.1	2,760,000	14.6
1904	45,635,300	11.4	65,643,600	13.6	37,783,100	26.6	20,069,200	14.5	2,901,300	6.5
1905	48,071,200	9.4	64,689,600	9.7	38,605,700	19.9	20,236,000	13.5	2,870,400	7.9

[a] Statistics corresponding to those of production not available.

Acreage and yield per acre of cereal crops in European countries—Continued.

SERVIA.

Year.	Wheat.		Rye.		Oats.		Barley.		Corn.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*
1893	783,500	11.1	147,800	8.9	261,800	12.5	227,600	11.1	1,314,100	13.8
1897	691,300	19.4	91,900	20.7	247,300	39.6	185,200	22.9	1,107,900	30.8
1898	695,900	14.0	111,700	14.2	235,100	27.4	237,200	16.9	1,235,700	22.8
1899	997,900	11.7	146,100	11.4	250,100	19.8	281,400	13.8	1,348,500	19.2
1900	766,100	10.6	87,900	7.7	210,600	12.7	184,900	12.2	1,144,900	16.1
1901	753,200	10.8	93,300	9.5	226,200	14.8	195,000	12.1	1,251,500	15.1
1902	804,600	14.2	98,400	11.0	248,100	16.3	217,900	16.0	1,296,400	14.2
1903	800,100	12.7	105,100	10.4	267,600	16.4	234,900	14.6	1,319,100	14.8
1904	905,400	12.9	111,500	9.2	259,100	12.2	244,700	12.9	1,336,600	7.1
1905	919,600	12.3	117,500	9.4	258,200	13.7	266,300	13.8	1,365,300	15.7
1906	921,400	14.3	120,200	13.0	261,500	17.7	270,200	17.6	1,354,500	20.5

SPAIN.

Year.	Wheat.		Rye.		Barley.		Oats.		Corn.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*[a]	*Acres.*	*Bush.*[b]	*Acres.*	*Bush.*[b]	*Acres.*	*Bush.*[b]	*Acres.*	*Bush.*[b]
1890	8,558,200	8.8	1,709,200	10.5	[illegible]	10.1	....	......	660,300	24.3
1892	8,366,800	10.4	....	......	....	......	....	......	....	......
1893	7,954,200	11.8	....	......	....	......	....	......	....	......
1894	8,252,100	13.3	1,518,100	11.5	2,518,200	23.0	730,100	17.0	826,000	23.1
1895	7,855,900	10.8	1,488,000	11.7	2,429,300	17.7	653,600	13.6	793,800	19.8
1896	7,825,200	10.1	1,674,200	9.2	2,360,600	13.8	683,100	11.5	993,300	18.4
1897	9,532,600	9.7	1,911,800	9.9	3,109,400	14.7	874,800	26.5	1,095,500	18.0
1898	9,543,100	13.1	1,775,800	11.9	3,689,900	19.7	938,000	18.1	1,036,000	14.7
1899	9,052,500	10.8	1,848,800	11.5	3,465,200	15.6	932,000	16.2	1,100,200	22.1
1900	9,550,700	10.5	1,799,000	11.9	3,432,400	16.5	937,200	17.5	1,175,700	22.1
1901	9,172,300	14.9	1,969,000	14.4	3,301,200	24.2	944,200	24.1	1,156,100	22.3
1902	9,150,100	14.6	1,937,900	13.5	3,599,900	22.6	1,111,800	21.0	1,142,700	22.1
1903	8,983,500	14.4	1,930,800	11.7	3,559,800	18.2	1,115,900	20.6	921,000	20.4
1904	9,023,000	10.6	1,889,900	9.1	3,413,900	15.8	1,103,400	16.7	1,072,000	19.8
1905	8,879,200	10.4	1,854,200	14.3	3,336,200	13.8	1,119,400	19.9	1,148,900	27.7

[a] In 1889-1890, bushels of capacity.

[b] Prior to 1897, bushels of capacity.

SWEDEN.

Year.	Wheat.		Rye.		Oats.		Barley.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]	*Acres.*	*Bush.*[a]
1890	174,400	23.2	964,500	22.4	1,979,200	32.0	546,200	27.0
1891	175,400	24.7	978,200	22.0	1,992,100	26.4	546,600	23.9
1892	176,300	24.6	987,900	23.3	2,010,800	32.1	550,100	25.2
1893	174,700	22.3	994,600	23.5	2,021,200	27.9	540,300	23.9
1894	175,100	24.9	994,100	19.4	2,022,000	31.4	540,700	26.4
1895	175,800	21.1	997,100	19.2	2,044,600	31.0	542,600	25.7
1896	176,200	26.7	1,007,500	23.0	2,023,000	26.2	538,700	25.2
1897	178,100	26.3	1,012,300	22.7	2,033,100	26.6	542,100	25.2
1898	182,800	25.2	1,014,200	20.4	2,034,700	32.0	545,700	27.2
1899	186,400	24.4	1,012,400	20.0	2,027,500	24.9	545,400	22.9
1900	192,500	28.0	1,015,800	23.3	2,038,200	30.7	537,600	25.7
1901	195,100	21.5	1,013,800	21.5	2,040,100	27.1	537,800	23.7
1902	202,400	23.5	1,017,200	21.9	2,036,100	28.2	531,400	23.1
1903	200,600	27.6	1,013,800	23.0	2,036,300	29.3	528,900	25.7
1904	199,900	25.7	1,016,500	20.4	2,045,900	25.2	526,300	25.6
1905	205,700	26.9	1,014,100	24.1	2,030,800	28.8	514,000	25.0

[a] Winchester bushels.

Acreage and yield per acre of cereal crops in European countries—Continued.

SWITZERLAND.

Year.	Wheat.		Rye.		Oats.		Barley.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*
1888	183,000	19.7	77,000	25.7	136,000	46.7	30,000	27.0
1889		19.5		22.2		43.4		25.4
1890		24.6		27.8		47.5		28.1
1891	174,000	24.2	79,000	25.6	139,000	48.6	30,000	27.5
1892		25.0		28.7		45.6		27.5
1893		18.8		22.5		30.3		22.0
1894	165,000	23.7	79,000	24.8	135,000	43.2	27,000	25.6
1895		20.9		21.5		43.5		25.0
1896		17.9		19.7		38.8		21.3
1897	160,000	21.5	88,000	23.0	144,000	44.0	27,000	24.2
1898	164,000	24.5	88,000	24.2	141,000	48.0	27,000	26.6
1899	164,000	24.7	88,000	25.9	140,000	47.9	27,000	25.8
1900		25.1		25.4		46.8		26.7
1901		22.0		24.0		41.3		24.4
1902		24.3		24.8		47.1		26.2
1903		25.9		26.6		49.4		28.0
1904	157,000	24.7	92,000	26.9	137,000	48.4	20,000	27.7
1905		22.3		24.9		45.4		25.9

GREAT BRITAIN.

Year.	Wheat.		Barley.		Oats.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.* [a]	*Acres.*	*Bush.*	*Acres.*	*Bush.*
1883	2,613,200	....	2,292,000	....	2,975,400	....
1884	2,677,000	30.9	2,168,800	35.2	2,915,400	38.7
1885	2,478,300	32.3	2,257,300	36.2	2,940,500	38.0
1886	2,285,900	27.7	2,241,200	33.2	3,081,600	39.0
1887	2,317,300	33.1	2,085,200	32.3	3,088,000	35.8
1888	2,564,200	28.9	2,085,600	33.9	2,882,300	38.4
1889	2,449,400	30.8	2,121,500	32.8	2,888,700	40.5
1890	2,386,300	31.7	2,111,200	36.1	2,903,000	42.7
1891	2,307,300	32.2	2,112,800	35.2	2,899,100	40.0
1892	2,219,800	27.2	2,036,800	35.7	2,997,500	40.0
1893	1,897,500	26.8	2,075,100	29.6	3,171,800	36.7
1894	1,928,000	31.7	2,095,800	35.6	3,253,400	42.9
1895	1,417,500	27.1	2,166,300	32.7	3,296,100	38.2
1896	1,694,000	34.7	2,104,800	34.7	3,095,500	38.0
1897	1,889,200	30.0	2,035,800	33.9	3,036,100	39.7
1898	2,102,200	35.8	1,908,700	36.9	2,917,800	42.0
1899	2,001,000	33.8	1,982,100	35.2	2,959,800	40.0
1900	1,845,000	29.4	1,990,300	32.3	3,026,100	39.1
1901	1,700,800	31.8	1,972,400	32.0	2,996,900	37.9
1902	1,726,400	33.9	1,909,400	35.9	3,057,000	44.0
1903	1,581,500	31.1	1,858,500	33.0	3,140,200	41.0
1904	1,375,200	27.7	1,840,700	32.1	3,252,900	40.4
1905	1,796,800	33.8	1,713,700	35.0	3,051,400	39.4
1906	1,755,600	34.7	1,751,200	35.7	3,043,000	41.8

[a] Winchester bushels.

Acreage and yield per acre of cereal crops in European countries—Continued

IRELAND.

Year.	Wheat.		Barley.		Oats.		Rye.	
	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.	Area.	Average yield.
	Acres.	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*	*Acres.*	*Bush.*
1883	94,700	25.5	183,600	35.9	1,381,900	47.7	7,200	22.9
1884	67,900	27.3	167,400	37.4	1,348,400	47.0	7,100	22.2
1885	71,000	28.8	179,500	37.6	1,328,900	47.8	8,400	25.4
1886	69,500	27.0	181,900	35.6	1,322,000	48.7	10,600	23.2
1887	67,200	28.3	162,400	29.8	1,315,100	40.3	10,800	21.6
1888	90,000	25.8	171,300	36.9	1,280,900	48.2	13,900	26.8
1889	89,700	29.9	186,300	40.7	1,239,000	49.8	15,800	25.8
1890	92,300	28.6	182,400	39.2	1,221,000	51.0	14,600	23.2
1891	80,900	32.3	178,300	43.4	1,215,400	54.2	13,400	27.1
1892	75,400	29.4	175,600	38.3	1,226,200	51.6	13,100	25.1
1893	55,000	30.3	169,000	38.3	1,248,300	54.4	13,500	26.5
1894	49,300	31.0	164,800	39.9	1,254,800	53.8	11,900	25.5
1895	36,500	30.4	171,800	38.7	1,216,400	52.4	11,500	26.7
1896	38,000	31.4	173,400	42.3	1,193,000	49.9	13,700	25.5
1897	47,200	28.7	170,700	35.4	1,175,100	48.4	13,100	21.7
1898	52,800	35.2	158,200	44.0	1,165,400	56.1	12,400	25.5
1899	51,900	33.4	169,700	41.8	1,135,500	55.2	12,100	25.7
1900	53,800	31.3	174,200	37.3	1,105,000	55.5	11,400	25.7
1901	42,900	34.2	161,700	42.1	1,099,300	56.6	11,000	27.3
1902	44,200	36.2	167,900	40.3	1,082,100	60.6	9,600	28.1
1903	37,600	31.3	158,800	38.3	1,097,500	53.6	10,000	26.9
1904	30,800	33.7	158,100	34.7	1,078,800	55.8	9,400	26.0
1905	37,900	37.8	154,600	46.4	1,066,800	56.9	10,200	27.0
1906	43,900	34.8	176,500	40.9	1,076,300	58.3	10,300	27.6

APPENDIX B.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, with respect to potash, phosphoric acid, lime, and magnesia.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
California [a]	1	0.555	0.230	0.955	1.052
Illinois	3	.161	.066	.210	.247
	5	.525	.106	.610	.643
Kansas	7	.643	.089	.575	.510
Indiana	9	.496	.166	.465	.450
Massachusetts	12	.153	.144	.525	.558
Michigan	14	.118	.064	.490	.275
Missouri	16	.272	.121	.405	.550
Montana	18	.731	.185	.870	.907
New York	19	.321	.189	.250	.518
South Dakota	22	.390	.153	.665	.628
Texas	25	.095	.032	.175	.162
Wisconsin	27	.230	.125	.405	.412
Illinois	35	.580	.085	.520	.806
Iowa	39	.337	.137	.790	.585
New York	51	.351	.156	.140	.585
California	63	.504	.163	1.535	1.726
	65	.508	.117	.900	1.542
Illinois	69	.156	.070	.230	.218
	70	.479	.185	1.455	.989
Indiana	73	.384	.105	.370	.450
Iowa	74	.365	.093	1.185	.662
Kansas	76	.766	.128	.675	.615
Michigan	80	.134	.066	.405	.281
Montana	84	.747	.176	.970	1.105
New York	85	.246	.202	.125	.549
South Dakota	87	[illegible]	.147	.710	.585
Texas	89	.053	.035	.150	.104
Wisconsin	90	.295	.163	.535	.457

[a] This and following samples, to and including number 90, analyzed by Moore, Jour. Am. Chem. Soc. 24, 85 (1902).

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Washington:[a]					
Yakima County	17	1.07	0.13	2.00	1.34
Kittitas County	37	.70	.18	2.08	1.47
Oregon,[a] Morrow County	79	.89	.18	1.37	1.08
Alabama[b]	....	.15	.017	.051	.01
Butler County	1129	.182	.029	.275	.293
Talladega County	1131	.908	.150	.289	.633
Pike County	1133	.149	.032	.039	.062
Arizona:[c]					
Glendale	3	.955	.244	2.213	2.535
	4	.528	.148	3.028	1.991
	5	.777	.220	2.721	2.441
	6	.472	.140	2.883	2.025
Granite Mountains	11	.671	.059	2.068	1.391
Orangewood	10	.630	.112	2.453	1.668
Tempe	17	.783	.080	1.336	1.317
	14	.503	.058	1.354	1.188
Glendale	1	1.025	.053	.981	1.764
	2	.563	.122	1.282	1.356
Orangewood	9	.800	.106	1.284	1.713
	7	.818	.207	2.703	2.326
Mesa	19	1.959	.227	1.240	2.102
	8	.970	.210	2.419	2.541
Tempe	16	1.094	.179	5.711	3.086
	18	1.045	.147	2.611	2.013
	15	.683	.149	3.513	1.466
Glendale	12	.777	.053	4.205	1.564
	13	.686	.045	2.854	1.447
Casa Grande	20	.534	.031	.579	.775
California, Needles[d]	21	.928	.185	6.427	....
California:[e]					
Amador County	1291	.64	.05	.20	.18
	1294	.26	.07	.17	.16
	1115	.53	.05	.50	.30
	1113	1.48	.05	.60	2.21
Butte County	1139	.28	.07	6.10	1.23
Shasta County	1028	.273	.041	.113	.306
Merced County	1192	.26	.03	.49	.33
Fresno County	1061	.418	.028	1.417	1.955
	1065	.29	.02	1.02	.63
	1055	.82	.07	1.14	1.58
	1189	1.32	.06	.99	1.54
	1190	.67	.16	1.31	1.74
	1191	1.01	.08	1.10	1.28
Alameda County	1029	.28	.70	8.21	.43
Santa Clara County	999	.31	.11	1.39	16.97
Napa County	1075	1.48	.08	.30	1.43
	1077	.67	.08	2.49	10.77
Sacramento County	880	.65	.08	.71	1.71
Contra Costa County	123	.24	.06	.66	.34
San Bernardino County	809	.79	.11	1.51	1.24
	812	.97	.05	1.65	1.68
	1406	.87	.14	1.57	1.33
	1536	.73	.07	1.58	1.85
	1537	.69	.03	1.71	1.78
	1248	.74	.09	1.11	1.40
	1251	1.17	.11	1.19	1.29
	1246	.68	.12	1.15	1.30
	1253	1.17	.11	.96	1.27
San Diego County	1238	.64	.06	1.06	....
	1092	1.42	.35	2.20	2.09
Arizona:					
Near Yuma	506	1.18	.13	8.67	2.97
Gila River Valley	1195	.66	.23	6.26	.66
California:[e]					
Sutter County	1645	.74	.24	2.06	2.13
Tehama County	1636	.50	.26	.81	1.14
Sacramento County	1698	.49	.20	1.45	.94
	1699	.62	.11	1.55	.94

[a] Hilgard, Weather Bureau Bul. No. 3, p. 18 (1892).

[b] Bul. 3, Alabama Agr. Expt. Sta., No. 3, p. 13.

[c] Bul. 28, Arizona Agr. Expt. Sta., pp. 77-92 (1898).

[d] Ann. Rep. Cal. Agr. Expt. Sta., 1890, pp. 23-50.

[e] Results for this and the following samples to and inclusive of 2411 from Ann. Rep. Cal. Agr. Expt. Sta., 1899-1901, 1893-4, 1894-5, 1895-1907; Nos. 2324 to 2430, inclusive, from Bul. 147, Cal. Agr. Ept. Sta. (1903); No. 2430 from Bul. 140, Cal. Agr. Expt. Sta. (1902).

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
California—Continued:		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Kern County	1466	1.04	0.22	1.29	1.24
Sonoma County	1647	.99	.16	.90	1.97
Napa County	1655	1.28	.09	.54	.91
Alameda County	1679	.73	.19	1.15	1.08
San Luis Obispo County	1693	.51	.29	1.04	.34
San Benito County	1704	.45	.16	1.16	2.09
Ventura County	1714	.47	.21	.07	.57
Riverside County	1758	1.37	.23	4.23	3.80
	1759	.84	.12	2.19	2.32
	1760	1.16	.28	8.00	5.69
	1761	1.01	.22	13.94	6.16
Orange County	1016	.80	.08	2.04	1.92
Tulare County	1159	1.20	.10	1.86	1.81
	1157	1.31	.14	1.70	1.96
	1163	1.24	.09	3.06	2.71
East Highlands	....	.98	.13	.96	1.42
Riverside	....	.87	.14	1.57	1.33
Corona	....	1.17	.11	1.19	1.29
Wheatland	2403	.42	.20	.72	1.45
	2405	.42	.14	.97	1.83
	2408	.65	.21	.83	1.50
	2411	.23	.09	.25	.29
Salton Basin	2324	.76	.23	4.35	1.24
	2325	.74	.22	3.75	1.68
Berkeley	2430	.33	.07	.76	.76
Colorado:[a]					
Arkansas Valley	1	.23	.23	2.80	.97
	2	.27	.22	1.28	.97
	3	.59	.21	3.69	1.61
Yuma	4	.39	.14	1.46	.69
Fort Collins	5	.56	.16	3.58	.73
	6	.62	.15	2.17	1.00
	7	.41	.21	.70	.85
	8	.66	.29	.91	.69
San Luis	9	.41	.23	.67	.54
	10	.27	.23	.81	.56
	11	.14	.14	.68	.67
Fort Collins	....	.41	.21	.70	.85
Florida:[b]					
Lake City	D	....	.02	.03	.02
	E	....	.70	.34	.13
	....	....	.07	.06	.03
	....	....	.02	.03	.05
Auburndale	16	....	.01	.10	.03
	....	....	.005	.007	.00
	....	....	.005	.008	.003
Tobacco soil	....	.018	.053	.130	.008
Tobacco soil (Cuban)	....	.160	1.60	7.60	.17
Pineapple soil	....	.006	.012	.000	.009
Orange soil	....	.014	.018	.034	.022
Cotton soil	....	.010	.032	Trace.	.020
Indiana:[c]					
Newton County	....	.47	.17	....	....
	....	.23	.22	....	....
Hendricks County	....	.680	.284	....	....
	....	.181	.222	....	....
Fountain County	....	.428	.123	....	....
	....	.281	.154	....	....
Delaware County	....	.32	1.01	....	....
	....	.35	.46	....	....
	....	.21	.16	....	....
	....	.22	.36	....	....
Kentucky:[d]					
Hodgenville	2003	.090	.172	.080	....
Lagrange	2004	.190	.182	.190	....
Beard	2130	.532	.096	.198	....
	2131	.515	.080	.175	....
Newport	2276	Trace.	.592	....	....
Lexington	2501	.510	.537	.605	.503
	2502	.480	.445	.425	.393

[a] Buls. 9 and 10, Colo. Agr. Expt. Sta. (1890).

[b] Bul. 5, Fla. Agr. Expt. Sta. (1899); Bul. 6 (1889); Bul. 19 (1893); Bul. 87 (1906).

[c] Bul. 95, Ind. Agr. Expt. Sta., pp. 25-29 (1903).

[d] This and following samples to and including No. 8590, Rep. Ky. Agr. Expt. Sta., 1892, 1893, 1894, 1899, 1901, 1902, 1903; Nos. 14398 to 14604, Bul. 126, Ky. Agr. Expt. Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Kentucky—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Casky	2600	0.310	0.117		
Meade	6039	.178	.030		
	6040	.249	.040		
	6041	.204	.055		
	6943	.214	.060		
	6944	.306	.039		
Shelbyville	7716	.096	.27	0.26	
Scottsville, Allen County	7720	.120	.015	.120	
Lincoln County	7885	.169	.014		
Logan County	8457	.397	.073		
Lewis County	8599	.251	.038		
Boone County	8810	.223	.090		
	8847	.234	.090		
Marshall County	8856	.308	.038		
	8857	.411	.042		
Kenton County	8897	.357	.094		
Breckenridge County	9541	.26	.07		
	9802	.160	.158		
Casey County	9800	.159	.069		
Fayette County	10249	.318	.475	.520	0.320
Henry County	9798	.264	.123		
Hopkins County	9623	.145	.052		
	9624	.165	.072		
Livingston County	10493	.471	.263		
	10494	.505	.230		
	10495	.475	.170		
	10496	.214	.030		
Pulaski County	9766	.141	.030		
Grayson County	11067	.148	.063		
Meade and Hardin counties	11068	.134	.074		
Henderson County	11188	.273	.077		
Hickman County	11170	.224	.080		
	11171	.440	.118		
Hopkins County	11174	.102	.064		
Lincoln County	10735	.160	.041		
Logan County	11119	.220	.155		
Boone County	14398	.206	.076		
Boyd County	14401	.130	.064		
Casey County	14407	.542	.058		
Clark County	14411	.710	.377	.500	.480
	14412	.732	.455	.600	.500
	14610	.549	1.335	.725	.280
	14613	.646	1.755	1.100	.240
	14654	.375	.855	.712	.400
	14618	.638	1.695	1.175	.320
	14648	.455	.485	.739	.420
	14616	.407	.710	.350	.200
	14650	.407	.512	.607	.520
	14652	.401	.755	.739	.480
Fayette County	14408	.380	.132		
	14409	.576	.182		
	14498	.417	.524		
	14577	.582	.302		
	14490	.405	.450	.400	.400
	14491	.400	.444	.475	.520
	14492	.380	.390	.400	.400
	14493	.410	.562	.600	.480
	14494	.407	.590	.650	.480
	14495	.452	.770	.725	.420
	14482	.435	.490		
	14483	.437	.474		
	14484	.337	.392	.300	.220
	14485	.347	.322	.350	.340
Henry County	14399	.278	.356		
	14477	.300	.274		
Knox County	14633	.125	.042		
Muhlenberg County	14636	.483	.120		
Ohio County	14410	.262	.040	.200	.300
Pendleton County	14400	.202	.096		
Rockcastle County	14480	.180	.038		
	14499	.350	.054		
Warren County	14509	.430	.070		
	14592	.188	.046		
	14593	.256	.055		
	14594	.307	.050		
	14595	.280	.025		

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Kentucky—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Woodford County	14513	0.340	0.428		
	14606	.472	.625		
	14604	.548	1.385	1.725	0.240
Louisiana[a]	1a	.100	.064	.170	.114
	2a	.120	.112	.060	.021
Maine,[b] Scarboro		.24	.29		
Maryland:[c]					
Washington County	133	.55	.50	.56	
	134	.35	.32	.56	
	463	.45	.24	.31	
Virginia,[c] Martinsburg	465	.43	.28	.12	
Maryland,[c] Washington County	466	.22	.20	.56	
	467	.32	.19	.31	
Michigan:[d]					
Lenawee County	1	1.84	.40	1.98	1.43
	2	2.05	.41	2.10	1.50
Washtenaw County	3	1.18	.40	1.28	.86
Cass County	4	1.18	.44	2.02	.66
	5	1.10	.33	1.38	.56
Shiwassee County	6	1.85	.49	1.64	1.23
Agricultural College	7	.85	.30	1.22	.59
	8	2.12	.41	1.28	.80
	9	1.97	.31	1.46	.43
Van Buren County	10	.83	.13	.51	.46
Lake County	11	.90	.23	.62	.28
Mason County	12	.65	.22	.66	.12
	13	2.10	.30	1.00	.89
Osceola County	14	1.19	.29	.80	.64
Mecosta County	15	1.96	.44	.94	.48
	16	1.80	.33	1.14	.49
Wexford County	17	.83	.15	.65	.24
Missaukee County	18	1.95	.28	1.15	.98
Grand Traverse	19	.89	.13	.37	.41
Benzie County	20	1.10	.21	.55	.27
Antrim County	21	.98	.18	.95	.36
Grayling	22	.20	.05	.20	.12
	23	.33	.04	.24	.17
	24	.30	.01	.32	.15
Kalamazoo	26	.34	.88	6.09	.81
Grand Haven	27	.20	.69	5.02	.62
Luce County	28	.42	.46	4.18	.75
Isabella County	29	.86	.19	.87	.27
Midland County	30	1.85	.49	1.64	1.23
Clare County	31	.54	.15	.36	.16
	32	.90	.36	.99	.73
Lake County	33	.73	.14	.35	.30
Gratiot County	34	.92	.14	.68	.30
Bay County	35	1.18	.38	1.18	.46
Montcalm County	36	1.13	.20	.82	.31
Otsego County	37	.61	.14	.40	.13
Iosco County	38	1.10	.16	.93	.36
Minnesota:[e]					
Red Wing	285	.15	.10	.47	.21
Gilford	265	.33	.10	.56	.38
Good Thunder	269	.46	.09	.60	.16
Langdon	290	.17	.15	.48	.20
Eden Prairie	304	.11	.22	.74	.41
Faribault County	300	.30	.19	.70	.40
Grant County	266	.21	.10	1.00	.42
McLeod County	234	.25	.20	.23	.36
Martin County	261	.31	.15	.58	.19
Meeker County	302	.25	.18	2.48	.97
Goodhue County	257	.16	.30	.76	.81
Warren	203	.54	.38	2.44	1.85
	298	.50	.31	2.40	1.91
Crookston	202	.60	.29	2.55	.67
	236	.54	.24	2.49	.62
	272	.90	.13	1.07	.84
Twin Valley	306	.18	.13	.43	.25
Gossen	308	.30	.19	1.20	.80

[a] Bul. 22, La. Agr. Expt. Sta., p. 739.

[b] Ann. Rep. Me. Agr. Expt. Sta., 1894.

[c] Ann. Rept. Md. Agr. Expt. Sta., 1889, p. 86.

[d] Bul. 99, Mich. Agr. Expt. Sta., 1893, pp. 6–15.

[e] This and the following samples to and including No. 257 from Ann. Rept. Minn. Agr. Expt. Sta., 1893; Nos. 203 to 329, Bul. 30, 41, and 65, Minn. Agr. Expt. Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Minnesota—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moorhead	275	0.73	0.20	1.29	0.39
	224	.45	.35	.60	.35
	312	.28	.30	.65	.77
	222	.18	.21	.61	.65
	259	.34	.21	1.00	.25
	249	.32	.26	1.53	.65
	298	.32	.25	.92	.24
Worthington	326	.36	.65	1.06	.82
Benson	214	.46	.27	13.56	2.57
Fergus Falls	208	.17	.32	.54	.33
Alexandria	210	.44	.31	1.26	.35
Wadena	245	.28	.20	.60	.60
Park Rapids	230	.26	.15	.61	.18
Henning	292	.19	.36	.63	.13
Fair Haven	273	.20	.21	.77	.25
Mille Lacs	216	.14	.22	.38	.29
Pine	236	.08	.04	.11	.12
Hinckley	228	.18	.12	.76	.25
New Duluth	232	.27	.33	.32	.51
Wyanette	288	.08	.10	.21	.13
Saint Cloud	212	.85	.19	.26	.10
Duluth	264	.25	.45	.51	.12
Farmington	277	.20	.20	.46	.18
	279	.19	.20	.48	.27
Rolling Stone	239	.30	.23	.41	.39
Faribault	280	.23	.21	.54	.30
Owatonna	283	.23	.13	.48	.18
Experiment station	242	.30	.28	.51	.26
Austin	218	.32	.38	.48	.45
Wells	220	.36	.25	1.10	.99
Mankato	294	.19	.30	.53	.11
Polk County	464	.84	.29	1.10	.59
Norman County	330	.43	.30	5.05	2.57
Polk County	317	.34	.27	.71	.63
Wilkin County	448	.37	.20	.89	.53
	446	.27	.22	1.36	.30
Lincoln County	428	.29	.15	.88	.73
Chippewa County	442	.38	.26	.56	.74
	444	.46	.26	1.05	.70
Kandiyohi County	414	.25	.21	.70	.43
Grant County	266	.21	.10	1.00	.42
Martin County	261	.31	.25	.58	.19
Meeker County	202	.25	.18	2.48	.97
Wright County	432	.13	.23	.69	.42
McLeod County	462	.17	.20	.95	.66
Hennepin County	430	.30	.38	.51	.50
	451	.29	.32	.92	.45
Ramsey County	374	.28	.19	.52	.21
Wadena County	420	.30	.45	.94	.51
Becker County	422	.25	.47	.88	.55
Todd County	418	.17	.31	.56	.26
	424	.16	.13	.47	.24
Ottertail County	456	.15	.16	.78	.17
Cass County	414	.27	.20	.28	.11
Dakota County	436	.32	.06	.31	.38
	434	.30	.28	.53	.40
Wabasha County	468	.27	.26	.67	.54
Goodhue County	285	.22	.10	.40	.17
	257	.26	.30	.76	.81
Rice County	489	.32	.16	.51	....
Houston County	483	.34	.32	.42	.47
Freeborn County	470	.27	.26	.60	.46
Fillmore County	487	.41	.12	.45	.66
Faribault County	300	.30	.19	.70	.40
Olmsted County	485	.61	.24	.30	.77
Blue Earth County	269	.46	.19	.60	.16
Washington County	440	.26	.19	.29	.43
	314	.17	.20	.28	.11
Chisago County	499	.20	.20	....	....
Pine County	426	.18	.13	.33	.29
	228	.25	.12	.76	.25
Carlton County	474	.12	2.61	.20	.39
Chisago County	497	.34	.10	.22	....
	495	.31	.11	.17	....
Pine County	501	.38	.22	.47	....

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Minnesota—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Dakota County	563	0.42	0.19	0.41	0.40
	567	.29	.16	.33	.34
	535	.44	.16	.46	.25
	513	.23	.36	.58	.69
Goodhue County	553	.40	.17	.64	.70
	521	.48	.16	.69	.61
	527	.51	.20	.70	.76
	616	.50	.20	.56	.23
	555	.44	.14	.49	.64
	577	.38	.16	.50	.51
	573	.37	.13	.59	.61
	572	.55	.17	.48	.51
Hennepin County	542	.43	.23	.42	.41
Wabasha County	515	.20	.31	.64	.72
	618	.44	.22	.41	.10
	503	.20	.38	.49	.44
Winona County	596	.38	.15	.43	.51
	597	.45	.26	.52	.45
	598	.44	.18	1.69	1.17
Freeborn County	592	.54	.27	.61	.53
	594	.46	.25	.67	....
	567	.42	.18	.52	.20
	584	....	.29	2.36	.77
	586	.29	.22	1.94	6.12
	519	.63	.11	.40	.57
Mower County	533	.37	.19	.49	.33
Fillmore County	633	.49	.32	3.22	.20
Waseca County	505	.21	.48	.53	.44
	465	.57	.22	.70	.29
Martin County	561	.57	.11	.93	.76
Watonwan County	531	.49	.15	.81	.54
	606	.45	.19	.40	.17
	607	.36	.19	.77	.37
	608	.46	.24	2.55	.20
Nicollet County	523	.52	.20	.62	.73
Sibley County	550	.43	.16	.63	.45
Renville County	511	.42	.32	.97	.60
Lyon County	599	.56	.24	.57	.67
Lac qui Parle County	568a	.50	.19	14.00	1.33
	502	.54	.29	1.65	.67
Big Stone County	537	.35	.20	.68	.73
Kandiyohi County	624	.56	.20	1.42	.38
	598	.34	.14	.72	.60
	590	.50	.18	1.31	.74
	620	.62	.21	.87	.11
Swift County	609	.33	.24	.56	.32
	525	.39	.16	.99	.27
Polk County	551	.57	.19	.74	.68
Ottertail County	517	.51	.16	.97	.61
	632	.44	.14	.71	.25
Becker County	571	.73	.16	.89	.76
Norman County	612	.66	.34	4.60	2.00
	613	.60	.32	8.67	1.69
	614	.73	.16	1.10	.60
Kittson County	569	1.16	.19	1.25	.58
Hubbard County	611	.20	.04	.48	.25
Isanti County	509	.10	.23	.38	.29
Sherburne County	579	.18	.11	.28	.21
Morrison County	575	.23	.14	.44	.34
Itasca County	540	.15	.11	.42	.30
	544	.55	.07	.74	1.04
	548	.18	.13	.19	.22
Beltrami County	666	.35	.14	.76	.36
Stearns County	600	.27	.10	.51	.24
	602	.37	.09	.27	.13
	630	.43	.21	.70	.37
Chisago County	529	.36	.30	1.22	.41
Mississippi:[a]					
Ocean Springs	692	.050	.027	.160	.072
	691	.036	.015	.230	.064
	695	.060	.004	.200	.028
Sentobia	1,480	....	.270	1.500	.400
McNeil Experiment Station	....	.142	.023	.220	.162
		.210	.017	.170	.149

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[a] This and following samples to and including 1480, Ann. Rpt. Miss. Agr. Expt. Sta., 1890; samples from McNeil Expt. Sta., Bul. 90, Miss. Agr. Expt. Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
North Dakota:[a]		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Red River Valley (average 21 samples)		0.54	0.19	4.16	0.81
James River Valley (average 5 samples)		.48	.27	1.07	.57
Cheyenne River Valley (average 2 samples)		.54	.17	14.67	.93
Mouse River Valley (average 4 samples)		.34	.18	2.19	.51
Devils Lake region (average 10 samples)		.57	.12	6.08	.61
Turtle Mountains (average 8 samples)		.55	.14	.77	.47
Wells County (average 2 samples)		.45	.19	.41	.28
Rolette County (average 7 samples)		.45	.25	.96	.14
West Missouri (average 2 samples)		.35	.19	.32	.43
Station farm	422	.45	.27	1.25	Trace.
	423	.44	.33	.83	Trace.
	424	.60	.38	.80	Trace.
	425	.73	.40	.86	Trace.
	426	.54	.38	1.01	Trace.
	427	.63	.30	.85	Trace.
	428	.50	.38	1.05	Trace.
Mayville, Old		.22	.37	2.10	.08
Mayville, New		.18	.31	2.00	.07
Station Plats	A	.77	.21	1.47	.72
	B	.61	.20	.65	.23
	1	.79	.27	1.08	.34
	2	.82	.29	1.30	.80
	24	.78	.38	1.07	.44
	25	.96	.30	1.19	.68
Oregon:[b]					
Lincoln County	1A	1.03	.06	.23	1.13
	1B	.10	.27	1.40	1.65
Washington County	1C	.03	.03	.34	1.71
	1D	.16	.32	.63	1.18
Wasco County	1E	.00	.02	.65	1.41
Washington County	1F	.12	.00	.75	7.13
	1G	.28	.34	1.35	.90
	1H	.26	.34	.76	.71
Benton County	1I	.11	.01	1.60	1.78
	1J	.47	.05	1.60	1.08
Polk County	1K	.24	3.26	.60	.55
Washington County	1L	.11	.30	1.47	1.27
Lincoln County	1M	.12	.08	.53	.82
Washington County	1N	.19	.06	.43	1.54
Lincoln County	1O	.26	.21	.31	.52
	1P	.28	.33	.30	.40
	1Q	.33	.12	.27	.25
	1S	.16	.08	.42	.98
	1T	.22	.12	.45	2.04
	1U	.33	.11	.27	.52
Lane County	1V	.09	.16	.60	.27
Linn County	1W	.15	.11	3.51	.21
Douglas County	1X	.44	.16	2.05	.42
Crook County	1Y	.83	.08	1.21	1.11
Union County	1Z	.81	.07	.76	.24
Washington County		.18	.23	1.49	.26
Marion County	2A	.66	.13	.97	.09
	2B	.04	.28	.10	.91
Baker County	406	.51	.14	1.13	1.93
	407	.03	.02	.94	.01
Polk County	409	.02	.02	2.01	.02
	424	.39	.47	.78	.87
Washington County	425	.02	.04	.82	.85
Marion County	426	.47	.63	.40	.96
Columbia County	447	.29	.31	.30	.80
Lincoln County	448	.11	.40	.46	.63
Washington County	449	.11	.25	.50	.00
	2N	.51	.54	.49	.71
	623	.17	.12	1.13	.38
	624	.23	.21	.64	1.45
Lane County	454	.19	.13	.65	.46
Polk County	625	.47	.22	.56	.79
Umatilla County	408	.23	.25	1.86	.09
Renton County	597	.33	.25	.89	.80
Jackson County	612	.33	.14	2.22	.83
	613	.21	.14	5.15	.72

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[a] This and the following samples to and including Mayville, N. Dak., from Bul. 35, N. Dak. Agr. Expt. Sta. (1899); samples A to 25, Ann. Rpt. N. Dak. Agr. Expt. Sta., 1902.

[b] Samples 1A to 627, Bul. 50, Oreg. Agr. Expt. Sta. (1898) samples 2383 to 2542, Ann. Rpt. Oreg. Agr. Expt. Sta. (1903).

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Oregon—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Josephine County	615	0.19	0.21	2.49	0.46
	615½	.27	.23	3.49	.43
Linn County	643	.39	.40	.50	.71
Wasco County	644	.12	.28	1.41	1.10
Marion County	626	.12	.29	.95	.62
	622	.46	.07	Trace.	.05
Multnomah County	629	.25	.40	1.27	1.23
Josephine County	616	1.85	.06	3.11	3.36
Douglas County	618	1.27	.28	.13	.08
Wasco County	702	.31	.22	.82	.15
	763	.20	.25	.38	.24
	764	.41	.82	.84	.24
Coos County	765	.20	.11	.52	.16
	766	.29	.38	.41	.60
Benton County	410	.06	.03	.66	.00
	411	.21	.34	.46	.05
Marion County	628	.48	.19	.32	.50
	628½	.52	.22	.34	.33
Yamhill County	768	.26	.23	.63	.63
	769	.38	.76	.43	.53
Marion County	619	.50	.35	.35	.22
	619½	.62	.30	.00	.28
Josephine County	617	.31	.05	.28	.35
	622	.30	.00	.72	.33
Marion County	627	.38	Trace.	.71	.91
	2382	....	.88	....	....
	2383	....	.15	....	....
	2407	.12	.23	.36	....
	2410	.15	.17	.24	....
	2425	.06	.11	14.36	....
	2448	.19	.21	.40	....
	2449	.18	.24	.33	....
	2450	.22	.20	.41	....
	2540	.26	.25	1.50	.64
	2541	.26	.39	5.63	2.19
	2542	.37	.36	1.25	.86
Washington[a]	5	.635	.142	1.081	.727
	11	.331	Trace.	1.512	1.527
	16	.530	.139	1.180	.733
	17	.432	.100	1.212	.788
	19	.202	.038	.655	Trace.
	20	.007	.054	.769	.426
	21	.136	.313	.379	.036
	22	.112	.079	1.112	.031
	25	.590	.353	.362	.281
	26	.233	.196	.397	.031
	27	.015	.140	.109	.022
	28	.277	.300	.082	.065
	29	.448	.345	.781	.122
	31	.650	.543	.431	.033
	32	.012	.311	.130	.033
	33	.047	.399	.398	.018
	34	.120	.172	.675	.116
	39	.274	.166	.979	.015
	40	.058	.159	1.758	.647
	41	.442	.191	.930	.382
Spokane County	30	.436	.265	.604	.438
	114	.374	.096	.644	.297
	119	.663	.070	.874	.073
	120	.651	.096	.908	.271
Jefferson County	42	.019	.109	.154	.335
	43	.022	.085	.579	.036
	175	.054	.089	.219	.212
San Juan County	44	.00	.105	1.468	.159
	45	.00	.365	.538	.432
	46	.00	.273	.448	.223
Okanogan County	71	.341	.112	2.084	.018
	74	.347	.286	4.679	.081
	76	.006	.096	.714	.011
	77	.019	.112	.614	.027
Whitman County	5	.635	.142	1.081	....
	72	.471	.361	.456	.238
	73	.322	.121	.332	.283

[a] Bul. 13, 23, and 55, Wash. Agr. Exp. Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Washington—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Whatcom County	75	0.006	0.294	0.324	0.546
	78	.142	.285	.409	.000
	79	.021	.067	.359	.151
	139	.316	.139	1.234	.454
	140	.483	.084	1.044	.112
	141	.275	.144	1.326	.000
	142	.319	.265	.891	.014
Skagit County	82	.111	.069	1.049	.009
	83	.057	.070	.832	.005
	84	.006	.045	.891	.005
	85	.014	.144	.891	.007
	86	.129	.207	1.061	.006
	100	.186	.304	.474	Trace.
	101	.028	.205	.518	.018
Yakima County	91	.189	.128	2.389	.092
	92	.140	.174	.909	.068
	93	.310	.141	1.259	.364
	94	.047	.153	1.409	.421
	137	.455	.029	1.154	.013
King County	102	.004	.057	.389	....
	129	.057	.070	.599	.216
	179	.142	.390	.404	.189
Thurston County	176	.076	.320	.506	.235
Snohomish County	103	.051	.176	.414	.018
	177	.218	.237	.704	.322
	105	.145	.067	.564	.357
	122	.625	.344	1.214	.209
	111	.154	.240	.524	....
	162	.335	.137	.333	.054
	37	.003	.205	.569	....
Clallam County	111	.154	.240	.525	.023
	128	.171	.115	.834	.450
Spokane County	115	.550	.154	.432	.306
	198	.534	.216	.630	.036
	199	.385	.190	.600	.054
Okanogan County	218	.147	.245	27.540	.005
Walla Walla County	289	.378	.320	1.200	.400
	290	.465	.287	1.450	.399
	291	.485	.351	1.350	.345
	292	.440	.320	1.550	1.003
Franklin County	293	.437	.351	1.050	.209
	294	.393	.325	1.300	.302
Kitsap County	80	.085	.048	1.971	.018
	81	Trace.	.019	.308	.281
	124	.111	Trace.	.659	.032
	126	.054	.045	.534	.036
	106	.008	.029	1.296	.476
Experiment Station Farm	373	.107	.177	.150	.010
	374	.129	.136	.175	.148
	375	.117	.192	.005	.109
	376	.092	.135	.010	.091
	378	.020	.336	.220	.091
Thurston County	184	.188	.312	.638	.048
	102	.004	.058	.389	.561
	231	.189	.297	.450	.112
Pierce County	37	.003	.205	.569	.048
	219	.181	.192	.940	....
	220	.144	.409	.760	....
Snohomish County	212	.146	.217	1.140	.091
	221	.150	.397	.520	....
King County	200	.087	.189	.410	.016
Utah:[a]					
College Farm	90	.046	.115	3.45	2.29
	93	.051	.103	3.08	2.52
Cache Valley, south end	2067	1.04	.18	.83	.50
	2074	.62	.18	.69	.55
	2162	1.15	....	.60	.49
	2070	.74	.24	.86	.67
	2079	1.48	.39	1.66	2.42
	2062	.60	.24	2.10	.56
Cache Valley, west side, south half	2058	.77	.19	.84	.65
	2065	.76	.24	.85	.64
	2071	1.34	.21	1.00	.98
	2073	1.50	.27	1.01	.72

[a] Ann. Rep. Utah Agr. Expt. Sta. (1891); Bul. 52, Utah Agr. Expt Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Utah—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Cache Valley, west side, south half	2163	1.43	0.27	1.25	0.86
	2160	1.34	.25	1.28	1.16
	2166	1.09	.42	1.55	.51
Cache Valley, west side, north half	2061	.47	.14	.46	.21
	2078	.67	.18	.99	.67
	2063	.68	.16	.67	.33
	2064	.71	.20	.69	.49
	2081	1.37	.29	1.31	.50
	2065	1.51	.25	.06	.89
Cache Valley, north end	2169	1.18	.15	1.85	.88
	2167	1.56	.30	3.14	.67
	2057	.50	.25	.67	.13
Cache Valley, east side	2065	1.16	.20	1.68	.54
	90	.05	.12	3.45	2.29
	93	.05	.10	3.08	2.52
	2059	1.39	.18	2.22	1.47
Middle Cache Valley	2172	1.05	.21	7.35	1.37
	2046	.53	.20	1.50	.21
	2047	.50	.25	2.43	.58
	2048	.60	.18	.59	.73
	2049	.30	.18	.54	.33
	2050	.44	.20	.56	.41
	2051	.90	.25	1.24	1.52
	2052	.31	.18	.17	.62
	2053	.36	.15	.22	.47
	2084	.69	.13	.69	6.39
	2083	.20	.26	1.11	8.36
Sanpete Valley	1819	.27	.16	.37	.13
	1818	.68	.21	9.81	.73
	1817	.72	.11	10.65	.07
	1816	.80	.22	13.09	.84
	1821	.51	.17	22.54	1.29
	1824	.65	.15	17.35	.29
	1826	.95	.20	14.89	.42
	1827	1.24	.24	13.16	.26
	1808	.58	.17	9.91	1.40
	1807	.67	.18	9.53	1.68
	1809	1.03	.19	14.01	1.20
	1805	.58	.14	12.84	.71
	1806	.95	.16	22.05	.85
	1825	.81	.17	13.17	1.80
	1811	.75	.23	13.99	.46
	1812	.60	.20	13.24	.59
	1813	1.25	.16	13.76	.75
	1814	.95	.12	13.17	.29
Wyoming:[a]					
Laramie Experiment Farm	5	.56	.15	1.47	.14
	7	.64	.14	.82	.76
Lander Experiment Farm	37	.68	.15	.64	1.36
	51	.61	.20	6.63	1.65
Saratoga Experiment Farm	19	.64	.12	3.41	.95
	43	.73	.13	.74	1.15
Sheridan Experiment Farm	33	.52	.28	.69	.94
Sundance Experiment Farm	27	.68	.18	4.97	3.21
Wheatland Experiment Farm	21	.63	.14	.87	.85
Tennessee[b]	1	.120	.040	.053	.140
	2	.180	.074	.060	.213
	3	.330	.104	.180	.342
	4	.312	.057	.163	.455
	5	.092	.021	.050	.085
	7	.403	.017	.073	.291
	6	.340	.022	.100	.265
	8	.218	.010	.100	.090
	9	.410	.158	.510	.290
	10	.393	.078	.278	.355
	11	.285	.020	.093	.157
	12	.378	.026	.132	.184
	13	.409	.069	.212	.270
	14	.380	.071	.205	.246
	15	.416	.113	.199	.290
Greene County		.092	.021	.050	.085
Knox County		.181	.074	.060	.213
		.120	.040	.053	.140
Grundy County		.403	.017	.073	.291

[a] Bul. 6, Wyo. Agr. Expt. Sta.

[b] Bul. 3, Tenn. Agr. Expt. Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Tennessee—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Franklin County		0.340	0.022	0.100	0.265
Monrôe County		.312	.057	.113	.455
Loudon County		.380	.104	.180	.342
Dyer County		.416	.113	.199	.290
Gibson County		.409	.069	.212	.270
Coffee County		.218	.010	.100	.090
Benton County		.285	.020	.093	.157
Carroll County		.378	.026	.132	.184
Fayette County		.380	.071	.205	.246
Maury County		.410	.158	.510	.290
Robertson County		.393	.078	.278	.35
New Hampshire [a]	1	.64	.36	.63	.62
	3_1	1.06	.16	.63	....
	3_2	1.06	.09	.76	.53
	5_1	.91	.08	.73	.74
	5_2	.97	.05	.77	.68
New York [b]	E	.95	.115	.60	1.02
	D	.89	.093	.62	.85
	D^2	.98	.134	.68	1.94
	F^1	1.04	.117	.70	1.04
Missouri [c]	1a	1.32	.08	.63	.44
	1b	1.23	.09	.55	.38
	2a	2.05	.07	.50	.45
	2b	1.90	.07	.50	.45
	3a	1.45	.06	.47	.29
	3b	1.45	.06	.42	.21
	4	1.72	.06	.62	.34
Nevada [d]	2	.364	.125	7.492	3.031
	3	.16	.040	9.580	2.332
	4	.128	.019	2.801	.574
	11	.488	.210	9.056	3.776
	12	.364	.125	7.492	3.031
	13	.616	.030	1.990	1.339
	14	.470	.104	11.549	2.810
	15	.628	.178	17.831	8.404
Nevada [e]	1	.313	.479	1.86	1.03
	2	.306	.291	7.716	1.570
	3	.016	.040	9.580	2.332
	4	.302	.157	2.447	1.403
	5	.457	.223	7.223	1.283
	6	.227	.163	1.503	.690
	7	.128	.019	2.801	.574
	8	3.34	.215	1.407	1.314
	9	.277	2.292	1.900	1.521
	10	.682	.190	2.001	1.470
	1501	.81	.35	2.50	1.18
	1503	1.12	.35	2.90	.23
	1504	1.03	.32	5.00	.17
	1523	1.79	.30	4.15	.23
	1533	.68	.41	.80	4.14
	1534	1.05	.26	5.15	.22
	1508	.51	.45	4.35	1.29
	1509	.97	.73	2.70	.21
	1510	.73	.27	3.30	1.09
	1511	.42	.19	2.45	1.08
	1512	.91	.28	2.20	.26
	1513	.42	.38	1.85	Trace.
	1514	.92	.79	2.30	.18
	1515	.54	.38	3.90	1.55
	1518	.43	.19	12.00	2.34
	1519	.32	.35	7.99	1.67
	1520	.42	.32	2.40	1.10
	1521	Trace.	.30	1.55	.96
	1523	Trace.	.26	14.65	1.81
	1533	.72	.26	12.50	5.10
	1534	.45	.35	8.10	2.02
	1545	.46	.55	1.60	1.06
	1546	.32	.26	1.20	.45
	1547	....	.38	1.85	.45
	1548	.32	.26	1.20	.45
	1549	.40	.38	1.48	.34

[a] Ann. Rept. N. H. Agr. Expt. Sta. (1893).
[b] Ann. Rept. N. Y. Agr. Expt. Sta. (1889).
[c] Bul. 5, Mo. Agr. Expt. Sta.
[d] Bul. 19, Nevada Agr. Expt. Sta.
[e] Bul. 39, Nevada Agr. Expt. Sta.; Ann. Rept. Nevada Agr. Expt. Sta. (1890).

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
West Virginia[a]	12	0.243	0.153	0.104	....
	13	.593	.121	.335	....
	14	.808	.167	.451	....
	15	.403	.105	.181	....
	16	.705	.103	.062	....
	17	.481	.088	.055	....
	46	.250	.115	.081	....
	47	.516	.185	.404	....
	48	.459	.184	.116	....
	49	.781	.095	.059	....
	50	.888	.121	.076	....
	51	.401	.093	.11	....
	53	.479	.211	.081	....
Ohio:[b]					
East farm, Wooster	840	.25	.07	.35	0.30
	844	.24	.081	.30	.43
	830	.20	.08	.27	.48
	834	.28	.08	.29	.28
	800	.15	.064	.21	.43
	804	.15	.061	.25	.43
	810	.16	.101	.37	.42
	814	.14	.089	.23	.42
	820	.16	.11	.25	.40
	824	.19	.129	.33	.40
	850	.29	.07	.32	.23
	852	.27	.079	.20	.35
	854	.25	.08	.24	.44
	856	.24	.099	.28	.37
	858	.20	.118	.25	.43
	860	.28	.08	.30	.36
South farm, Wooster	872	.28	.151	.225	.368
	876	.27	.118	.187	.375
	862	.39	.167	.24	.45
	866	.29	.191	.20	.39
	868	.34	.156	.208	.358
University farm, Columbus	1	.64	.12	.64	.76
	4	.53	.20	.60	.52
	7	.62	.12	.59	.71
	10	.55	.17	.46	.64
	13	.59	.15	.45	.61
	16	.53	.10	.63	.58
	19	.62	.11	.68	.62
	22	.43	.12	.45	.49
Test farm, Strongville	1852	.18	.097	.20	.44
	1864	.25	.064	.16	.31
	1868	.22	.121	.10	.54
Test farm, Strongville	1874	.21	.099	.19	.34
	1880	.20	.08	.23	.40
	1884	.25	.12	.28	.40
	1810	.23	.197	.19	.42
	1820	.19	.161	.18	.56
	1826	.19	.113	.27	.461
	1832	.28	.227	.30	.57
	1838	.20	.126	.354	.44
	1844	.11	.126	.23	.54
	1846	.15	.121	.22	.50
Northwest test farm, Neapolis	1802	.50	.11	.11	.09
	1806	.50	.16	.49	.18
	1803	.60	.10	.80	.14
	1807	.60	.12	.41	.15
	1786	.046	.120	.07	.10
	1792	.060	.130	.31	.14
	1787	.040	.110	.07	.11
	1793	.090	.120	.22	.15
Germantown	4253	.142	.102	.11	.31
Carpenter test farm	4255	.193	.124	.18	.33
	4257	.181	.101	.18	.26
Wooster experiment farm, first 12 inches	....	.25	.80	.313	.356
Strongville, first 12 inches	....	.251	.145	.205	.474
Columbus, O. S. U., first 12 inches	....	.563	.143	.621	.623
Neapolis, first 12 inches	....	.043	.115	.070	.105

[a] Bul. 28 and 99, W. Va. Agr. Expt. Sta.

[b] Bul. 110 and 150, Ohio Agr. Expt. Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Oklahoma:[a]		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Virgin soil, Statute farm	7	0.44	0.06	0.95	0.21
Virgin soil	10	.80	.04	.44	.16
Virgin soil	5	.32	.06	.76	.18
Pennsylvania:[b]					
Donegal		.62	.191	.61	1.26
Rocky Springs		.67	.265	.41	2.05
Connecticut,[b] New Milford		.23	.22	.32	.78
North Carolina,[b] Granville County		.02	.02	.07	.02
Sumatra,[b] gray soil		.22	.11	.77	.37
Cuba:[c]					
San Antonio		.190	.555	.270	.190
Zorilla		.165	.475	.350	.210
South Carolina,[d] Spartanburg farm	13	.142	.057	.027	.081
	17	.090	.066	.037	.043
	15	.100	.011	.045	.110
Columbia farm	1	.171	.044	.019	.040
	3	.050	.107	.022	.072
	5	.089	.022	.046	.124
Darlington farm	19	.052	.034	.025	.043
	21	.050	.037	.062	.047
	23	.040	.051	.028	.003
Big River		.541	.155	.188	.811
Rhode Island:[e]					
Kingston plain		.155	.127	.509	.209
Kingston upland		.175	.106	.448	.264
Warwick		.124	.029	.410	.290
Lime Rock		.184	.098	1.295	1.141
Block Island		.136	.067	.273	.209
Middletown		.164	.099	.252	.368
East Providence		.126	.120	.495	.356
Tennessee:[f]					
Hamblen County	58	1.21	.37	.08	.13
	55	.10	.03	.10	.12
Knox County	606	.08	.03	.12	.22
	31	.14	.03	.09	.11
	48	.16	.05	.13	.20
Hamblen County	64	.23	.04	.16	.17
Knox County	25	.28	.09	.17	.15
McMinn County	172	.38	.06	.12	.37
Hamblen County	60	.28	.10	.04	.13
	66	.08	.01	.09	.11
Knox County	32	.29	.09	.11	.10
	602	.26	.08	.12	.22
	608	.09	.03	.08	.15
Hamblen County	51	.85	.10	.82	.42
	57	.36	.07	.17	.25
Knox County	29	.43	.07	.22	.24
	821	.26	.09	.10	.30
McMinn County	174	.68	.07	.31	.53
Roane County	595	.18	.07	.06	.12
Washington County	597	.18	.07	.10	.18
Anderson County	129	.21	.17	.12	.19
Hamblen County	49	.24	.08	.12	.24
Knox County	600	.36	.16	.30	.29
	603	.41	.18	.38	.73
	30	.34	.09	.20	.35
	37	.18	.16	.18	.31
	553	.18	.11	.16	.22
Roane County	503	.30	.09	.26	.33
Blount County	35	.52	.18	.17	.56
Hamblen County	53	.91	.09	.73	.96
Knox County	26	.45	.12	.43	.48
	612	.41	.09	.41	.52
Cumberland County	605	.06	.03	.10	.10
	746	.18	.06	.06	.27
	67	.08	.02	.04	.14
Cumberland County	68	.06	.03	.04	.16
Coffee County	750	.23	.07	.23	.21
Franklin County	39	.31	.09	.21	.30
	565	.27	.10	.16	.23
	566	.34	.04	.14	.27

[a] Bul. No. 5, Okla. Agr. Expt. Sta.

[b] Ann. Rep. Pa. Agr. Expt. Sta. (1894).

[c] Ann. Rep. Pa. Agr. Expt. Sta. (1901).

[d] Ann. Rep. S. C. Agr. Expt. Sta. (1889).

[e] Bul. 28, R. I. Agr. Expt. Sta.

[f] Bul. 3, Tenn. Agr. Expt. Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Tennessee—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Humphreys County	592	0.23	0.05	0.13	0.26
Lawrence County	569	.16	.08	.08	.21
	570	.28	.06	.08	.31
Montgomery County	742	.22	.05	.14	.23
Stewart County	581	.15	.05	.12	.18
	583	.17	.51	.15	.18
White County	571	.20	.06	.14	.16
	574	.22	.07	.13	.49
	563	.21	.07	.09	.28
	564	.32	.05	.14	.34
Coffee County	867	.09	.04	.14	.15
Dickson County	591	.16	.03	.08	.24
	589	.10	.03	.10	.15
	590	.31	.02	.02	.49
Houston County	585	.15	.03	.10	.19
	586	.12	.03	.04	.24
	583	.15	.05	.09	.18
	579	.13	.09	.34	.16
Lewis County	587	.18	.02	.06	.17
	588	.25	.04	.03	.35
Putnam County	843	.07	.03	.06	.11
Warren County	806	.14	.04	.09	.14
	575	.08	.01	.07	.13
	580	.11	.01	.07	.13
Bedford County	751	.28	.14	.09	.37
	615	.17	.08	.28	.19
	616	.15	.08	.25	.21
	572	.33	.12	.24	.33
	573	.40	.05	.31	.42
	577	.46	.19	.57	.44
	578	.19	.05	.05	.19
	747	.26	.16	.14	.24
	748	.30	.11	.10	.27
	170	.32	.26	.20	.32
	171	.42	.17	.18	.40
	175	.43	.14	.56	.36
	176	.43	.15	.61	.34
Davidson County	617	.70	.06	.46	.79
Lincoln County	42	.44	.31	.31	.53
Marshall County	561	.19	.32	.20	.30
	633	.25	.26	.17	.28
	660	.33	.27	.27	.35
Rutherford County	635	.29	.08	.22	.23
Smith County	822	.22	.21	.17	.21
Sumner County	634	.24	.20	.23	.26
	160	.33	.26	.38	.28
	161	.29	.25	.20	.38
Williamson County	567	.33	.32	.20	.32
	568	.50	.97	.18	.23
Carroll County	662	.21	.07	.16	.21
	661	.32	.05	.10	.41
Chester County	659	.20	.11	.19	.21
Dyer County	664	.24	.08	.16	.25
Gibson County	158	.21	.06	.16	.25
	159	.26	.06	.11	.37
	668	.23	.08	.23	.23
Hardeman County	670	.35	.09	.22	.33
Henderson County	658	.23	.07	.16	.21
Henry County	663	.23	.07	.15	.21
Madison County	749	.31	.09	.09	.43
McNairy County	671	.20	.06	.11	.19
Obion County	669	.28	.09	.39	.42
Weakley County	666	.23	.07	.20	.24
	665	.34	.06	.11	.40
	667	.28	.08	.16	.26
Blount County	135	.76	.24	.24	.52
Giles County	576	.34	.52	.38	.34
	584	.42	.70	2.25	.35
Roane County	594	.09	.04	.09	.23
White County	883	.22	.07	.13	.23
Montgomery County	871	.20	.05	.15	.23
	874	.38	.16	.25	.38
Maury County	885	.31	.21	.29	.35
Sumner County	873	40	.38	.43	.39

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Oregon:[a]					
Salem	2697	0.15	0.41	0.37	0.76
	2698	.20	.53	.48	.41
	2699	.26	.21	.80	.30
	2700	.12	.21	.54	.27
	2701	.44	.34	.32	.13
	2702	.39	.18	.45	.13
Hubbard	2097	.08	.24	.28	....
	2095	.14	.38	.31	....
	2096	.30	.40	.45	....
	2513	.19	.24	.71	.56
	2525	.21	.19	.08	.87
	2539	.20	.26	.78	.85
	2554	.28	.14	1.11	.56
	2591	.10	.45	.94	.48
	2592	.18	.23	.29	.11
	2616	.51	.20	1.26	.90
	2617	.30	.22	.84	1.27
	2618	.13	.20	1.22	.79
	2619	.25	.21	1.98	1.31
	2621	.17	.19	1.09	.71
	2627	.19	.12	1.18	.29
	2623	1.16	.23	1.92	1.00
	2635	.10	.38	.54	.33
	2637	.17	.31	.48	.46
	2638	.16	.39	.67	.39
	2644	.26	.20	.76	.73
	2649	.12	.41	.67	.28
	2650	.16	.34	.94	.29
	2656	.09	.16	.55	.60
	2658	.10	.38	2.89	.60
	2689	.18	.36	.59	.18
	2690	.28	.26	1.44	.55
	2691	.43	.30	.91	.80
	2710	.43	.43	.53	.00
	2751	.43	.18	.45	.00
	2754	.37	.31	1.40	.95
	2758	.38	.58	.24	.79
	2781	.34	.89	.31	.91
	2838	.39	.22	.67	.80
	2841	.13	.14	.85	.48
	2843	.38	.25	.77	.44
	2844	.27	.34	.91	.35
	2847	.44	.25	.74	.58
	2848	.14	.24	.43	.35
	2854	.26	.16	.88	.46
	2855	.52	.39	.69	.67
	2869	.31	.25	.68	.76
	2921	.97	.24	1.35	1.24
Beaverdam soils	1	.14	.26	1.09	.22
	2	.28	.31	.26	.06
	3	.13	.22	.47	.10
	4	.10	2.30	.92	.33
	5	.20	.21	1.18	.25
North Carolina:[b]					
Oxford		.161	.16	.240	.047
Washington:[c]					
Spokane County	564	.829	.249	7.768	3.891
	641	.438	.108	.320	.112
	642	.304	.157	.334	Trace.
	643	.356	.300	.524	....
	1030	.389	.185	.618	....
Stevens County	77	.492	.122	.741	.150
	78	.225	.048	.741	.239
	161	.074	.083	.400	.234
	342	.162	.280	.350	.175
	435	.193	.400	.508	.374
	436	.229	.343	.494	.602
	655	.412	.217	.640	1.218
	656	.320	.089	.590	.469
	673	.338	.192	.499	.515
	1103	.099	.082	36.009	.684

[a] Ann. Rep. Oregon Agr. Expt. Sta. (1905); Bradley Jour. Am. Chem. Soc., *28*, 64 (1906).

[b] Bul. 90, N. C. Agr. Expt. Sta.

[c] Bul 85, Wash. Agr. Expt. Sta.; Bul. 10, Div. of Chemistry, U. S. Dept. Agr., 1886.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Washington—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ferry County	446	0.204	0.124	0.581	0.548
	1872	.323	.257	.961	.262
	1873	.384	.241	.760	.216
Okanogan County	789	.294	.145	.668	.162
	790	.335	.170	.944	.319
Chelan County	158	.118	.078	.379	.301
	576	1.114	.122	1.365	.897
	1885	.518	.225	.714	.186
	1886	.649	.240	.852	.522
Lincoln County	741	.436	.117	.842	.581
	742	.524	.150	.755	.746
	1890	.517	.172	.563	.070
Douglas County	868	.335	.155	5.561	.976
	1024	.312	.050	1.120	.445
	1241	.298	.125	.568	.568
	1242	.442	.147	.762	.642
	1416	.382	.102	.563	.171
Adams County	1609	.450	.042	.618	.684
	1837	.411	.120	.591	.258
Whitman County	1888	.506	.187	.568	.194
Garfield County	1134	.567	.127	.726	.847
Asotin County	1133	.320	.080	.609	.632
	1420	.434	.052	.480	.239
	1431	.426	.042	.535	.095
	1432	.391	.047	.549	.210
Walla Walla County	1098	.358	.050	.824	.306
	1842	.413	.142	1.998	.140
	1845	.328	.037	.650	.104
	1846	.426	....	.770	.140
Columbia County	1135	.467	.110	.755	.793
	1411	.431	.162	.803	.437
	1412	.287	.152	.831	.509
Benton County	142	.427	.165	3.451	1.458
	708	.329	.105	1.570	1.009
	743	.312	.140	.944	.650
	745	.288	Trace.	.987	.712
	767	.301	Trace.	1.721	.940
	782	.415	Trace.	1.250	.582
Yakima County	194	.212	.136	1.631	.703
	545	.144	.130	1.770	1.270
	662	.293	.102	1.078	.500
	667	.125	Trace.	.648	Trace.
Kittitas County	722	.471	.112	1.190	.793
	723	.462	.063	2.134	.850
	751	.79[illegible]	.187	14.012	4.830
Klickitat County	8	.359	.150	.663	.385
	9	.413	.184	.390	.416
	190	.147	.069	.365	.354
	512	.028	.032	.790	Trace.
	1025	.116	.067	.550	....
Skamania County	661	.385	.138	.540	.297
	1102	.318	.118	.452	....
Clarke County	172	.166	.243	.486	.547
	330	.066	.198	.200	....
	331	.178	.426	.862	.674
Wahkiakum County	602	.354	.212	.552	.228
	603	.610	.105	1.542	.982
	604	.134	.062	.145	....
Lewis County	783	.071	.062	.653	.405
	784	.162	.297	.769	.455
	785	.224	.107	.479	.086
	786	.124	.002	.421	.189
	1772	.184	.182	.164	.428
Chehalis County	143	.223	.118	.379	.256
	144	.144	.390	.393	.713
Mason County	869	.146	.155	1.525	.657
	1656	.440	.192	1.338	.703
	1657	.495	.192	1.433	.659
	1658	.475	.224	1.329	.465
	1659	.545	.224	2.099	1.411
	1660	.535	.216	1.418	.973
	1661	.940	.224	1.428	.947
	1662	.700	.224	1.449	.991
San Juan County	394	.154	.300	.873	.906
	870	.180	.125	1.060	.630
	871	.162	.087	1.031	.481

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Washington—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
King County	159	0.126	0.044	0.615	0.807
	160	.157	.073	.693	.548
	499	.125	.206	1.069	.398
	500	.153	.190	1.069	.658
	744	.193	.124	1.321	.602
Dakota:[a]					
Prairie soils	6	.720	.112	.848	.868
	16	.725	.112	.852	1.535
	7	.745	.224	3.898	2.007
Michigan:[b]					
Berrien County		.180	.715	.967	.267
Indiana:[b]					
Boone County		.510	.041	1.387	.771
New York:[b]					
Oswego County	A1	.320	.023	.350	.389
	A2	.425	.052	.440	.501
	A3	.305	.023	.350	.274
	A4	.595	.050	.564	.641
	B5	.400	.010	.753	.555
	B6	.475	.048	1.873	.868
	B7	.480	.038	.535	.642
	C8	.530	.176	[illegible]	.893
	C9	.460	.176	[illegible]	.746
Louisiana:[b]					
Rapides Parish	2574	1.470	.160	1.1[illegible]5	2.169
	2575	.930	.144	2.0[illegible]0	1.066
	2576	1.940	.193	.836	2.547
	2577	.805	.113	.414	1.131
	2579	.430	.097	.185	.346
	2580	.165	.00	.111	.090
	2581	.745	.080	.371	.839
	2582	.805	.096	.926	1.934
Nebraska:[c]					
Dawes County		.041	.822	1.892	.205
Cherry County		.410	.062	.498	.084
Brown County		.741	.062	.773	.060
Antelope County		.592	.039	.595	.031
Saunders County		.241	.112	.490	.334
Lancaster County		.197	1.421	.612	.420
Hamilton County		.054	.094	.468	.439
Mills Farm		.806	.137	1.007	1.080
Division B		.593	.156	.715	.860
Wisconsin:[d]					
Experiment plat—					
Poor		.26	.18	1.44	....
Medium		.27	.20	1.35	....
Good		.30	.22	1.05	....
(Red Clay)	127	1.27	.08	.75	2.08
Clark County	61	.08	.17	.63	.73
University farm	119	.37	.13	.53	.80
Shicoton	71	.17	.27	.83	.56
Lacder Flambeau	48	1.81	.18	1.05	.57
Peat	21	.46	.25	1.74	.44
Muck	22	1.43	.23	1.82	1.47
Virgin soil, University farm		.37	.13	.53	.80
Texas:[e]					
Terrell		.17	.28	.55	.28
Pecan Gap		.83	.13	.81	.32
Forney		.316	.326	11.00	.543
Prairie soil		.837	.313	6.62	.81
Hammock		.68	.25	6.30	.46
Manor, Travis County		.576	.115	5.81	.317
Bell County, Waxie		.22	.12	23.98	.94
Bell County, Hammock		1.45	.18	1.03	.73
Waxahachie		.35	.15	5.17	.67
New Braunfels		.22	.41	7.32	1.31
Abilene		11.37	Trace.	4.04	1.40
Wichita		.426	Trace.	.074	Trace.

[a] Bul. 10, Div. of Chemistry, U. S. Dept. Agr., 1886 (locality unknown).
[b] Bul. 10, Div. of Chemistry, U. S. Dept. Agr., 1886.
[c] Bul. 60, Nebr. Agr. Expt. Sta.
[d] Ann. Rep. Wis Agr. Expt. Sta. (1905).
[e] Bul. Nos. 25, 35, 45, 61, 82, and 99, Texas Agr. Expt. Sta.; Ann. Rep. Texas Agr. Expt. Sta. (1889).

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Texas—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
El Paso		0.52	0.34	0.57	Trace.
		.43	.60	3.83	Trace.
Fort Bend		.46	.166	2.74	0.24
Brazoria		1.09	.136	1.66	.126
		.885	.34	5.66	1.85
		.545	Trace.	.600	.73
Brazos River		.885	.34	5.66	1.85
Brazos Bottom		.46	.196	2.74	.24
		.856	.136	1.66	.126
		.545	Trace.	.600	.73
Kaufman County		.68	.25	6.30	.46
		.316	.326	11.00	.542
		.887	.313	6.62	.81
Manor		.576	.115	.581	.317
New Braunfels		.22	.41	.32	1.31
Waxahachie		.35	.15	5.17	.67
Bell County		.22	.12	23.98	.94
		1.45	.18	1.03	.73
Pecan Gap		.83	.128	.814	.32
Terrell		.17	.82	.55	.28
Cherokee		.48	.243	.35	.126
Ridge soil		Trace.	.07	.16	Trace.
Pine Ridge		Trace.	Trace.	.00	.00
Tyler County		.06	.03	.44	.08
		Trace.	Trace.	.00	.08
		1.14	Trace.	4.04	1.41
Wichita County		.426	Trace.	.07	Trace.
College Clay		.80	.083	.60	.06
Alvin	1	.93	.024	.958	.464
	2	.46	.22	6.33	1.46
	3	.56	.15	8.17	2.01
Harris County		.17	.12	1.62	......
Hitchcock	1	......	.04	.21	.695
	2	......	.035	.165	Trace.
	3	......	.037	.40	.08
	4	......	.019	.66	.122
Mess		.397	.074	3.56	1.06
Beeville	1	.32	.04	.76	.47
	2	Trace.	.01	.67	.41
	3	Trace.	.06	.60	.13
Carsin's farm	14	.02	.04	.17	.09
	16	.05	.05	.08	.05
	18	.01	.008	.04	.08
Huntsville	1	.05	.07	.09	.08
	2	.06	.06	.07	.18
	3	.05	.07	.18	.18
Willis	1	Trace.	.01	.18	.14
	4	.06	.01	.20	.27
	5	.37	.04	.16	.18
	7	.01	.03	.16	.28
	9	.04	.01	.04	.09
	11	.05	.29	.06	.18
Rice soils	95	.08	.016	.24	.18
	96	.29	.036	.55	.50
	97	.137	.019	.53	.70
	137	.143	.026	.24	.26
	141	.06	.023	.09	.16
	206	.396	.025	2.17	.83
Harris County		.29	.156	.65	.27
Victoria County		.43	.093	1.05	1.09
Brazoria County		.78	.148	1.88	1.91
Brownsville		1.31	.204	14.43	1.53
Houston County—					
Norfolk sand		.10	.01	.28	.31
Fine sand		.13	.01	.10	.03
Fine sandy loam		.18	.02	.09	.11
Orangeburg fine sand		.14	.05	.14	.06
Fine sandy loam		.71	.05	.10	.08
Lufkin fine sand		.11	.03	.15	.63
Clay		.14	.01	.43	.07
Susquehanna fine sandy loam		.11	.03	.05	.09
Clay		.20	.02	.29	.29

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Texas—Continued.					
Anderson County—		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Norfolk sand	....	0.07	0.02	0.05	0.05
Fine sand	....	.10	.02	.06	.07
Fine sandy loam	....	.13	.01	.04	.05
Orangeburg fine sandy loam	....	.13	.03	.02	.04
Clay	....	.22	.06	.23	.22
Yazoo clay	....	.50	.14	3.14	.75
Lamar County—					
Orangeburg sandy loam	....	.25	.05	.12	.07
Fine sandy loam	....	.76	.02	.06	.07
Silt	....	.78	.12	1.52	.61
Clay	....	.40	.05	.08	.20
Houston black clay	....	.39	.05	1.05	.80
Clay	....	.19	.02	.35	.32
Sharkey clay	....	.83	.11	1.20	1.25
Lufkin clay	....	.13	.03	.07	.11
Sanders loam	....	.12	6.04	.38	.25
Travis County—					
Houston black clay	....	.29	.07	5.66	.68
Yazoo sandy loam	....	.28	.07	10.60	1.06
Travis gravelly loam	....	.52	.04	1.47	.16
Lufkin fine sandy loam	....	.11	.02	.91	.10
Bexar County—					
Norfolk sand	....	.05	.02	.04	.02
Sandy loam	....	.17	.02	.05	.14
Houston black loam	....	.80	.06	3.06	.73
Clay	....	.32	.08	1.16	1.83
Orangeburg fine sand	....	.25	.02	.18	.01
Clay	....	.45	.09	.35	.35
Portsmouth sandy loam	....	.23	.03	3.40	.37
San Antonio clayey loam	....	.47	.08	8.06	4.01
Austin fine sandy loam	....	.03	.11	23.64	.62
Hays County—					
Houston loam	....	.29	.01	.37	.23
Black clay	....	.20	.08	19.61	.62
Clay	....	.04	.09	19.32	.44
Crawford sandy clay	....	.58	.18	12.40	.30
Silt clay	....	.78	.10	1.58	.83
Blanco loam	....	.05	.12	34.91	.91
Susquehanna fine sandy loam	....	.34	.40	.70	.20
Wabash clay	....	.41	.15	9.86	.96
Rio Grande Valley	1	....	.12	3.53	Trace.
	2	....	.29	2.06	.15
	3	....	.36	3.79	Trace.
Tyler County	....	.06	.03	.44	.08
Cherokee County	....	.48	.03	.36	.14
Arkansas [a]	14727	.17	.07	.10	.14
	14728	.36	.10	.08	.29
	14729	.15	.07	.10	.20
	14730	.34	....	.07	.22
	15353	.22	.16	.15	....
	15354	.30	.09	.08	....
California [a]	6356	1.07	.37	1.49	2.97
	6359	1.12	.53	1.47	3.39
	6831	.09	.05	.26	.21
	7936	.40	.16	4.46	1.75
	8051	1.81	.02	1.36	....
	8063	1.52	.05	1.06	....
	10147	.72	.14	.66	1.00
	8432	.33	.05	1.20	1.74
	6621	.92	.25	1.08	1.89
	6035	.11	.03	.67	.90
	6330	1.13	.30	1.29	2.22
	6352	1.84	.23	1.34	2.52
Miscellaneous	....	.55	....	2.82	1.18
	....	.31	....	2.20	1.53
	....	.54	....	1.96	1.73
	....	.29	.06	....	....
	....	.48	.06	1.79	....
	....	.34	.03	....	....
	....	1.20	.21	1.92	....
	....	1.01	.09	1.61	....

[a] Analyses made by the Bureau of Soils, U. S. Dept. of Agr.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Colorado[a]	7962	0.52	0.22	4.26	1.13
	7964	.61	.26	5.40	1.09
	723a	.71	.36	1.13	....
Miscellaneous	....	.88	.06	5.14	.60
	....	.57	.09	1.52	.19
	....	.89	.13	2.54	.45
	....	.82	.08	4.05	.20
	....	.80	.11	2.03	.28
	....	.79	.12	2.23	.21
	....	1.27	.22	2.10	.23
	....	.68	.22	.63	.48
	....	1.02	.22	2.74	.62
	....	.72	.11	.80	.13
	....	.61	.15	.40	.62
	....	.81	.22	.54	.19
	....	.89	.35	2.60	.80
	....	.54	.30	6.00	.36
	....	.56	.24	.45	.40
District of Columbia[a]	6548	.53	.07	.57	.19
	726a	.20	.07	.26	.02
	727a	.29	.07	.26	.02
	728a	.36	.05	.26	.01
Florida[a]	2822	.04	.93	.24	.07
	3965	.03	....	.03	.16
	5284	.20	.02	.10	.07
	5286	.17	.08	.12	.05
	5288	.18	.02	.07	.06
	5290	.19	.08	.15	.07
	5391	.04	.05	.12	.01
	5392	.05	.04	.08	.02
	5403	.06	.04	.05	.01
	5404	.07	.06	.02	.03
	5405	.07	.04	.06	.01
	5406	.09	.09	.04	.03
	5407	.11	.19	.07	.08
	5408	.07	.17	.18	.02
	5409	.08	.08	.21	.02
	5410	.10	.08	.05	.03
	5413	.09	.06	.12	.01
	5414	.05	.04	.09	.02
Georgia[a]	6263	.12	.06	.14	.15
	6364	.09	.06	.09	.13
Kansas:[a]					
Miscellaneous	....	.18	.09	....	....
	....	.54	.10	2.84	.66
	....	.26	.11	....	.36
	....	.20	.13	3.23	.62
	....	.53	.11	.17	....
Kentucky[a]	7565	.28	.03	.05	.08
	13715	.39	.05	.24	.49
	13716	.31	.05	.24	.43
	13717	.23	.05	.29	.37
	13718	.29	.04	.23	.41
	1096	1.06	.25	.23	.51
Louisiana[a]	733	.71	.19	.54	.57
	734	.76	.18	.66	.70
Maryland[a]	132	.41	....	.44	.69
	5400	.38	.06	.21	.34
	5459	.91	.11	.11	.18
	5456	.44	.10	.11	.47
	5455	.89	.05	.15	.40
	5454	.86	.09	.14	.14
	1099	.46	.20	1.26	....
	749a	.15	.04	.09	....
	804a	.06	.04	.09	.05
Minnesota[a]	15355	.73	.24	6.45	....
	15356	.63	.17	13.83	....
	15357	.15	.24	1.22	....
	15358	.15	.15	1.07	....
	15359	.14	.23	1.03	....
	15360	.17	.13	.60	....
Mississippi[a]	7935	.31	.24	.83	1.23

[a] Analyses made by the Bureau of Soils, U. S. Dept. of Agr.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Nebraska[a]	....	0.91	0.19	2.35	1.22
	....	.96	.26	1.95	.42
	....	.99	.26	3.07	.65
	....	.54	.29	2.35	.47
	2089	.10	.30	.24	.03
	6832	.08	.02	.19	.09
New Jersey[a]	....	1.20	.28	.24	....
Nevada:[a]	5685	1.00	1.25	1.27	3.23
Miscellaneous	....	.72	.12	1.45	1.23
	....	.69	.20	1.81	1.60
	....	.99	.17	1.86	1.42
	....	.66	.20	1.56	1.31
	....	1.07	.16	1.78	1.48
	....	.73	.15	1.70	1.21
	....	.62	.21	1.80	1.51
North Dakota[a]	6549	.92	.10	.92	1.37
Pennsylvania[a]	1119a	.35	.16	.08	....
	....	.30	.17	.09	....
State College	....	.46	.12	.31	.54
	....	.40	.11	.26	.47
	....	.47	.11	.23	.46
	....	.42	.12	.25	.41
	....	.47	.11	.25	.42
	....	.40	.01	.25	.45
	....	.44	.03	.26	.55
	....	.44	.13	.24	.52
	....	.26	.11	.33	.44
	....	.35	.16	.34	.43
	....	.49	.13	.29	.56
	....	.43	.11	.25	.55
	....	.38	.11	.23	.42
	....	.41	.12	.24	.45
	....	.42	.11	.24	.50
	....	.39	.14	.27	.50
	....	.40	.11	.26	.53
	....	.38	.13	.23	.49
	....	.30	.15	.36	.47
	....	.26	.12	.31	.38
South Carolina[a]	3961	.02	.76	.59	.26
Texas[a]	2165	.13	.02	.67	.06
	2167	.08	.02	.15	.16
	808a {	.06	.03	.22	.09
		.02	.02	.27	.09
	790a	.82	....	7.25	1.17
	12481	1.64	.14	2.67	....
	12482	1.20	.10	6.88	....
Virginia:[a]					
Miscellaneous	....	1.02	.16	.14	....
Washington[a]	40004	.06	.30	.09	.18
Wisconsin[a]	6546	.57	.11	1.11	1.01
California:[b]	798a	1.51	.05	.37	....
Eldorado County	1638	.55	.23	.52	.38
Stanislaus County	1901	.98	.06	.61	.51
	1900	.49	.05	.61	.51
Tulare County	1903	.97	.15	.79	1.22
	1904	.87	.05	.73	.64
Ventura County	1910	.84	.14	.74	1.27
Los Angeles County	1820	1.60	.31	2.73	2.87
	1908	.41	.23	1.95	2.04
	1906	1.18	.21	2.66	1.79
	1907	1.01	.15	2.49	1.75
Inyo County	1756	.46	.08	.95	.79
Eldorado County	2214	.31	.15	.38	.69
Shasta County	2181	.40	.06	1.34	.67
Modoc County	2169	.41	.25	3.65	2.55
Glenn County	2291	.23	.22	1.53	.42
Yuba County	2403	.42	.20	.72	1.45
	2405	.42	.14	.97	1.83
Humboldt County	2319	.61	.30	.44	1.76

[a] Analyses made by the Bureau of Soils. U. S. Dept. of Agr.
[b] Ann. Rep. Cal. Agr. Expt. Sta., 1895-1397, 1901-3.

Chemical composition of the soils of the United States, Great Britain and Ireland, France and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesi (MgO).
California—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Mendocino County	2243	0.95	0.15	1.40	2.55
	2433	1.41	.28	1.69	2.35
Lake County	2301	.61	.08	2.51	1.37
	2295	.84	.12	2.34	.50
Contra Costa County	2454	.53	.07	4.50	1.83
Alameda County	1880	1.17	.19	1.38	2.68
	2430	.33	.07	.76	.76
San Luis Obispo County	2061	.67	.71	2.11	2.26
Ventura County	2273	.49	.06	.35	.80
Riverside County	2234	1.00	.16	1.80	1.64
San Diego County	1936	.18	.11	1.47	.58
Riverside County	2470	.80	.14	2.69	.75
	2471	1.26	.21	2.71	2.20
San Diego County	2324	.76	.23	4.35	1.24
	2325	.74	.22	3.75	1.68
Florida,[a] Dade County	10	.0065	.0240	.0250	.0060
	14	.0043	.0240	.1275	.0612
	19	.0178	.0256	.0725	.0351
	18	Trace.	.0304	.5500	.0036
Lee County	1	.0164	2.5920	6.6050	.0290
	25	.0058	.0208	Trace.	.0299
	26	Trace.	.0496	.0725	.0198
	28	.0125	.0112	.0000	.0117
	50	.0024	.0128	.0700	.0261
De Soto County	4	.0212	.0160	.0750	.1126
	64	.0072	.0028	.0000	.0369
Brevard County	12	.0086	.0336	.2100	.0225
	13	.0111	.0192	.1075	.0099
	21	.0612	.0544	2.2325	.0307
	38	Trace.	.0416	.0400	.0000
	40	.0034	Trace.	.0000	.0634
	X	.0198	.0333	.1150	.0197
Osceola County	47	.0077	.0032	.0225	.0144
	49	.0073	.0096	.0150	.0282
	51	Trace.	.0144	.0000	.0234
Polk County	42	.0038	.0064	.0000	.0090
	43	Trace.	.2708	.0125	.0531
	44	Trace.	2.4000	.1125	.0090
	45	.0028	.3112	.0175	.0414
	55	Trace.	.0272	.0125	.0291
	57	Trace.	.0240	.0000	.0102
Hillsboro County	75	.0028	.3408	.2025	.0443
	116	.0023	.0880	.2650	.0126
Pasco County	73	.0048	.1360	.0250	.0126
Orange County	31	Trace.	.1328	.0275	.0390
	60	Trace.	.0816	.0000	.0270
	62	.0193	.0272	.0000	.0086
	Y	.0160	.1175	.0025	.0175
Volusia County	6	.0048	.0112	.0500	.0297
	8	.0164	.0577	.0225	.0275
	Z	.0208	.1640	.0526	.0145
Marion County	33	.0149	.2544	.1500	.0198
Florida:[b]					
Miami	1296	.0135	.0162	.1740	.0176
	1298	.0170	.0075	.1587	.0222
	1300	.0170	.0062	.0312	.0149
Bocaratone	1302	.0097	.0087	.0187	.0000
	1304	.0145	.0087	.0062	.0000
West Palm Beach	1306	.0140	.0087	.0087	....
	1308	.0048	.0100	.0037	....
	1310	.0097	.0087	.0062	.0092
	1312	.0145	.0137	.0287	.0158
Jensen	1314	.0061	.0120	....	.0065
	1316	.0073	.0056	.0112	.0049
	1318	.0061	.0087	.0087	.0058
Eldred	1320	.0110	.0431	.0862	.0511
	1322	.0134	.0106	.0137	....
St. Petersburg	1380	.0134	.0056	.0162	.0068
	1382	.0134	.0556	.0312	.0357
Oneco	1384	.0122	.0106	.0187	.0168
Punta Gorda	1386	.0170	.0187	.0850	.0171
	1388	.0110	.0050	.0475	.0144
Orlando	1390	.0188	.0250	.0350	.0422
Key	1411	.2963	.9450	4.7250	1.5750

[a] Bul. 43, Fla. Agr. Expt. Sta.

[b] Bul. 68, Fla. Agr. Expt. Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Idaho:[a]		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Kootenai County	9	....	Trace.	1.32	0.03
	20	....	0.45	.94	1.16
Latah County	17	0.50	.49	2.80	.51
	19	.01	1.57	.13	.19
Shoshone County	5	.04	.35	.78	.72
Nez Perce County	31	.034	.25	3.75	.91
Grangeville	13	.04	.62	1.49	2.52
	14	.40	.01	1.44	.34
	15	1.92	.01	.64	.22
Canyon County	1	....	.31	2.70	.58
	6	....	1.20	.69	1.60
	7	....	.09	Trace.	.57
	8	....	.19	.65	.38
Bingham County	21	1.16	1.39	.07	.31
	22	1.22	.47	2.50	.29
	23	1.28	.41	2.15	.14
	24	.9[illegible]	1.16	2.08	1.25
	25	1.04	.21	.06	1.09
Bear Lake County	26	1.44	.31	1.43	.37
	27	.72	.19	3.94	3.15
	29	1.12	.05	.59	3.15
	30	.72	.94	5.92	1.24
Cassia County	4	.775	.183	1.971	1.387
	5	.605	.137	1.870	1.322
Cœur d'Alene	7	.440	.188	.533	1.290
	9	.467	.205	.432	1.527
Nez Perces	11	.450	.188	.507	.905
American Ridge	....	.684	.157	.557	.907
Latah County	13	.673	.131	.722	1.019
	14	.557	.026	.767	.802
Lewiston	15	.526	.148	.872	1.150
Moscow	16	.563	.192	.939	.886
	18	.667	.176	.999	.766
Boise	20	.789	.237	1.567	1.090
	21	.896	.184	.893	1.006
	22	.450	.141	.465	.535
	23	.572	.143	.780	.831
Louisiana:[b]					
Calhoun	1	.023	.037	.065	.018
	2	.029	.048	.145	.074
	3	.011	.021	.027	.027
	5	.008	.011	.009	.011
Monroe	7	.069	.072	.128	.180
	9	.023	.007	.040	.036
Mississippi:[c]					
Agricultural College	48	.125	.148	.45	.32
	50	.153	.092	.161	.12
	49	.122	.092	.161	.12
	51	.126	.114	.307	.47
	52	.303	.204	.400	.68
	53	.104	.156	.770	.60
	54	.127	.233	.370	.47
	55	.132	.149	.610	.60
	56	.117	.182	.440	.60
	57	.097	.185	.64	.56
	58	.131	.102	.54	.39
	59	.150	.147	.83	.79
	60	.111	.096	.40	.53
	61	.145	.181	.63	.40
	62	.116	.118	.39	.12
	162	.12	.08	.14	.10
	163	.06	.08	.22	.06
Union County	606	.31	.089	.86	.061
Jackson County	602	.050	.027	.16	.072
	604	.056	.015	.23	.064
	605	.080	.004	.20	.028
Chickasaw County	888	.10	.26	.27	.22
Covington County	1522	.09	.184	.302	.318
	1523	.08	.100	.280	.126
Noxubee County	1524	.18	.24	4.91	.144
Oktibbeha County	1536	.25	.097	.47	.38
Tallahatchie County	1538	.46	.257	.94	.25

[a] Buls. 9 and 28, Idaho Agr. Expt. Sta.

[b] Special Rep. on the Geology and Agriculture of the Hills of La., La. Agr. Expt. Sta. (1892).

[c] Ann. Rep. Miss. Agr. Expt. Sta., 1895 and 1898-99; Bul. 65, Miss. Agr. Expt. Sta.

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Mississippi—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Hinds County	1544	0.10	0.07	0.66	0.38
Oktibbeha County	1572	.22	.192	1.85	.302
Holmes County	1696	.24	.190	.25	.08
Crystal Springs	928	.07	.07	.175	....
Coffeeville	400	.20	.09	.27	.24
	401	.18	.09	.22	.28
	402	.09	.06	.15	.17
	403	.17	.08	.19	.25
	404	.14	.06	.19	.19
Yazoo City	421	.365	.127	2.14	.11
Como	75	.143	.27	.58	.023
	76	.147	.232	.084	.023
Elizabeth	209	.55	.16	.34	.20
Noxubee County	937	.218	.085	.985	....
	939	.478	.189	1.56	....
	940	.463	.121	1.45	....
	941	.426	.121	1.13	....
	948	.360	.046	.990	....
	935	.201	.090	.325	....
	946	.450	.105	.945	....
	949	.372	.105	.465	....
	951	.245	.079	.325	....
	942	.400	.263	1.16	....
	943	.500	.302	15.57	....
	944	.509	.321	5.24	....
	945	.574	.296	5.15	....
Oktibbeha County	585	.460	.300	.630	....
	617	.300	.144	1.88	....
	620	.280	.093	5.90	....
	621	.360	.262	1.03	....
	622	.210	.108	.380	....
	583	.380	.427	.315	....
	594	.200	.108	.280	....
	595	.420	.229	.190	....
	597	.165	.147	.32	....
	585	.460	.300	.630	....
Copiah County	801	.203	.064	.150	....
	822	.200	.040	.155	....
Madison County	881	.257	.040	.165	....
	884	.180	.042	.145	....
	886	.225	.039	.265	....
Amite County	1021	.125	.055	.095	....
Wilkinson County	1026	.166	.033	.080	....
Panola County	994	.241	.055	.140	....
	983	.322	.064	.125	....
	976	.293	.102	.170	....
Oktibbeha County	833	.337	.079	.185	....
Choctaw County	904	.246	.075	.160	....
Leake County	844	.189	.050	.205	....
Scott County	850	.150	.049	.185	....
Choctaw County	906	.197	.037	.105	....
Winston County	911	.133	.022	.100	....
Neshoba County	836	.247	.087	.165	....
Scott County	853	.270	.097	.235	....
	855	.210	.044	.100	....
Winston County	913	.160	.044	.155	....
Kemper County	919	.199	.060	.130	....
Harrison County	674	.098	.033	.180	....
Jones County	1010	.123	.046	.200	....
	1012	.160	.035	.150	....
	1013	.208	.024	.111	....
Kemper County	926	.076	.110	.192	....
	928	.465	.156	1.08	....
	929	.185	.072	.980	....
	931	.263	.053	.535	....
Noxubee County	932	.442	.188	.960	....
	933	.148	.084	.210	....
	935	.201	.090	.325	....
	937	.218	.085	.985	....
	939	.478	.189	.156	....
	940	.463	.121	.145	....
	941	.426	.121	1.130	....
	942	.400	.263	1.18	....
	943	.500	.302	15.57	....
	944	.509	.321	5.24	....

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Mississippi—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Noxubee County	945	0.574	0.296	5.15	....
	946	.450	.105	.945	....
	948	.300	.046	.990	....
	949	.372	.105	.485	....
	951	.245	.079	.325	....
Lowndes County	1153	.358	.111	3.56	....
	1154	.387	.140	3.71	....
	1155	.283	.093	.315	....
	1157	.268	.123	.360	....
Oktibbeha County	581	.39	.096	.11	....
	584	.92	.57	1.06	....
	585	.46	.30	.63	....
	586	.210	.115	.235	....
	593	.177	.14	.180	....
	594	.20	.108	.23	....
	595	.42	.229	.19	....
	597	.165	.147	.32	....
	617	.30	.144	1.88	....
	620	.28	.093	5.90	....
	621	.36	.262	1.03	....
	622	.21	.108	.38	....
	1106	.491	.328	2.69	....
	1107	.470	.143	.265	....
	1108	.423	.274	2.25	....
	1117	.300	.096	.950	....
	1118	.480	.121	12.52	....
	1119	.181	.105	.117	....
	1121	.152	.097	.175	....
	1122	.150	.083	.100	....
	1111	.215	.055	.800	....
	1113	.305	.070	1.06	....
	1280	.276	.075	.900	....
	1124	.454	.332	.200	....
	1126	.177	.119	.170	....
	1114	.398	.114	1.20	....
	1115	.262	.080	.800	....
	1158	.331	.188	.940	....
Clay County	1159	.193	.051	.650	....
	1161	.395	.184	1.53	....
	1162	.369	.244	1.24	....
	1163	.302	.207	1.36	....
	1165	.258	.113	.430	....
Monroe County	1168	.502	.191	1.82	....
	1169	.364	.109	1.11	....
	1172	.401	.174	6.26	....
	1174	.208	.089	1.50	....
	1175	.370	.153	.680	....
Chickasaw County	1178	.305	.115	1.06	....
	1179	.198	.036	[illegible]	....
	1180	.258	.054	.890	....
	1181	.402	.140	5.80	....
	1182	.135	.047	.100	....
	1274	.189	.056	.110	....
	1276	.262	.064	.150	....
Lee County	1184	.385	.160	1.20	....
	1185	.340	.134	.815	....
	1186	.321	.210	1.61	....
	1187	.216	.210	3.27	....
	1189	.297	.237	1.27	....
	1190	.395	.194	1.47	....
	1191	.158	.068	.235	....
	1193	.402	.185	.940	....
	1194	.269	.118	.470	....
	1200	.200	.083	.500	....
	1202	.250	.076	.340	....
	1204	.096	.032	.053	....
	1206	.179	.253	9.63	....
	1209	.129	.065	.160	....
	1213	.086	.025	.030	....
Prentiss County	1211	.220	.090	.510	....
	1217	.098	.036	.190	....
	1219	.103	.043	.120	....
	1221	.102	.065	.120	....
	1223	.321	.329	11.93	....
	1225	.226	.129	.810	....

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Mississippi—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Prentiss County	1227	0.273	0 174	0.340	....
	1229	.105	.009	.070	....
	1234	.088	.018	.072	....
	1250	.089	.027	.205	....
	1253	.359	.092	1.32	....
	1254	.122	.051	.160	....
	1256	....	.114	1.05	....
	1257	.565	.140	.830	....
Alcorn County	1241	.147	.071	.235	....
	1245	.185	.051	.245	....
	1247	.129	.040	.175	....
	1248	.157	.050	.140	....
Union County	1261	.276	.048	.190	....
	1263	.187	.035	.160	....
	1265	.170	.038	.190	....
	1266	.203	.052	.140	....
	1268	.258	.093	.205	....
	1030	.190	.024	.110	....
Pontotoc County	1269	.336	.167	.142	....
	1272	.333	.094	.106	....
Alcorn County	1236	.178	.072	.145	....
Madison County	625	.215	.062	.29	....
	629	.20	.076	.22	....
	633	.170	.083	.17	....
	879	.250	.061	.120	....
	881	.257	.040	.165	....
	883	.396	.068	.145	....
	884	.180	.042	.145	....
	876	.326	.022	.300	....
	886	.225	.039	.265	....
Leake County	890	.281	.018	.110	....
	892	.160	.019	.110	....
	894	.165	.022	.025	....
	895	.093	.016	.05	....
Attala County	897	.190	.030	.115	....
	898	.229	.044	.210	....
	900	.160	.047	.130	....
	902	.105	.013	.050	....
Choctaw County	904	.246	.075	.160	....
	905	.177	.024	.050	....
	906	.197	.037	.105	....
Carroll County	958	.363	.080	.120	....
	960	.276	.188	.135	....
	961	.222	.104	.160	....
	963	.298	.051	.100	....
	965	.408	.078	.110	....
	967	.436	.090	.120	....
	969	.170	.050	.125	....
Yalobusha County	971	.180	.023	.015	....
	973	.311	.044	.065	....
	974	.212	.053	.140	....
	975	.223	.063	.145	....
Panola County	976	.293	.102	.170	....
	977	.335	.168	.200	....
	978	.333	.117	.130	....
	979	.323	.070	.190	....
	981	.426	.064	.170	....
	983	.322	.064	.125	....
	985	.373	.080	.185	....
	988	.304	.135	.120	....
Tate County	991	.183	.066	.190	....
	994	.241	.055	.140	....
	996	.262	.064	.220	....
	997	.303	.071	.165	....
	1000	.43	.097	.050	....
	1001	.26	.069	.150	....
Marshall County	1003	.253	.041	.300	....
	1007	.360	.083	.225	....
	1008	.252	.079	.275	....
Amite County	1021	.125	.055	.095	....
	1023	.17	.067	.175	....
	1025	.242	.057	.125	....
	1026	.166	.033	.08	....

Chemical composition of the soils of the United States, Great Britain and Ireland, France, and Germany, etc.—Continued.

CHEMICAL COMPOSITION OF THE SOILS OF THE UNITED STATES—Continued.

State or Territory.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
Mississippi—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Hinds County	871	0.168	0.040	0.190	....
	873	.182	.057	.210	....
	875	.277	.050	.105	....
Neshoba County	834	.170	.052	.075	....
	836	.247	.087	.165	....
	838	.163	.045	.080	....
Scott County	853	.270	.097	.235	....
	855	.210	.044	.10	....
	856	.309	.058	.20	....
	848	.190	.025	.095	....
	849	.202	.066	.285	....
	850	.150	.049	.135	....
Leake County	844	.189	.050	.205	....
	846	.165	.048	.170	....
Scott County	852	.130	.082	.085	....
Neshoba County	954	.563	.117	.300	....
Copiah County	801	.203	.064	.15	....
	803	.223	.058	.0[illegible]5	....
	805	.297	.064	.1[illegible]5	....
	807	.190	.061	.1[illegible]5	....
	809	.170	.040	.140	....
	810	.286	.047	.1[illegible]5	....
	811	.263	.068	1.20	....
	813	.173	.05	.0[illegible]0	....
	816	.300	.107	.255	....
	818	.196	.149	.225	....
	820	.233	.081	.215	....
	822	.200	.060	.155	....
	823	.277	.065	.120	....
	824	.253	.050	.285	....
	825	.251	.060	.100	....
	826	.262	.077	.150	....
	827	.128	.064	.095	....
	828	.134	.047	.115	....
	830	.199	.060	.130	....
	831	.264	.064	.125	....
Jones County	832	.132	.036	.125	....
	1010	.123	.046	.20	....
	1012	.160	.035	.15	....
Harrison County	674	.098	.033	.18	....
Winston County	913	.160	.044	.155	....
	915	.145	.055	.100	....
Kemper County	917	.140	.074	.068	....
	919	.199	.060	.130	....
Winston County	911	.133	.022	.100	....
Neshoba County	921	.090	.028	.020	....
Kemper County	923	.141	.019	.070	....
	925	.345	.029	.170	....
Scott County	858	.129	.013	.195	....
	859	.255	.029	.725	....
Rankin County	861	.290	.052	.220	....
	862	.194	.040	.185	....
	864	.240	.080	.115	....
	865	.230	.097	.125	....
	867	.193	.062	.125	....
Oktibbeha County	833	.337	.079	.185	....
Rankin County	869	.115	.057	.15	....
Washington County	269	.55	.16	.34	....
Bolivar County	676	.46	.17	.126	....
	677	6.87	.192	.92	....
	678	6.92	.195	.89	....
	679	.941	.216	.97	....
Coahoma County	700	.54	.092	.40	....
	701	.54	.14	.41	....
	702	.84	.134	.59	....
	703	.36	.115	.34	....
Jasper County	658	.415	.118	.372	....
	659	.50	.109	.245	....

Chemical composition of the soils of Great Britain and Ireland.

ENGLAND.

County.	Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Dorset[*]	Alluvium	38	0.46	0.42	3.84	0.48
		62	.22	.23	1.30	.11
		41	.81	.46	1.00	.26
	Gravel	36	.22	.32	.71	.45
		37	.33	.28	.64	.27
		63	.18	.26	.11	.04
		64	.17	.20	.11	.05
	Bagshot beds	83	.19	.18	.37	.02
		30	.13	.25	1.43	.34
		40	.18	.20	.80	.17
		65	.13	.12	.08	.06
	London clay	80	.23	.32	.37	.12
		12	.22	.47	1.26	.31
		68	.20	.15	.36	.07
	Reading beds	81	.27	.33	.66	.27
		11	.27	.40	1.57	.68
		67	.24	.21	.65	.07
		61	.06	.11	.33	.02
	Junction Reading beds and chalk.	39	.24	.42	1.83	.27
	Chalk	15	.25	.30	41.00	.83
		71	.27	.29	38.78	.65
		99	.19	.78	31.50	.53
		95	.29	.47	31.05	.11
		51	.20	.33	32.10	.27
		94	.22	.49	14.22	.15
		35	.28	.24	5.59	.71
		50	.39	.36	35.70	.27
		16	.59	.33	33.40	.71
		72	.50	.27	10.31	.43
		49	.20	.31	2.22	.19
		21	.39	.25	1.81	.39
		100	.38	.51	1.40	.47
		1	.17	.44	.90	.41
		98	.47	.36	1.01	.39
		96	.42	.31	1.30	.06
		97	.57	.26	.34	.28
	Greensand	79	.35	.37	.44	.08
		47	.81	.60	.92	.46
		48	.74	.79	7.10	1.00
		2	.40	.23	2.19	.59
	Junction green sand and marlstone.	31	.27	.32	1.45	.27
		25	.29	.28	.71	.68
	Wealden beds	33	.31	.31	1.02	.41
		32	.25	.44	1.36	.34
		84	.24	.29	.66	.32
		69	.36	.28	.96	.11
		22	.31	.50	.92	.27
	Purbeck beds	27	.34	.29	1.82	.48
	Portland stone	66	.46	.43	.51	.07
	Kimmeridge clay	3	.30	.15	2.10	.55
		20	.4	.6	2.10	.5
		42	.47	.89	2.22	.09
		85	.61	.38	2.52	.43
		86	.81	.24	1.87	.51
		87	.95	.34	1.76	.42
		88	.92	.50	1.18	.51
	Coral rag	19	.38	.31	.67	.96
		77	.63	.32	6.35	.54
		82	.39	.47	10.53	.54
		89	.53	.60	18.65	.60
		8	.27	.40	20.70	.36
		57	.68	.35	2.03	.09
		58	.49	.32	12.05	.20
	Calcareous grit	9	.25	.31	.80	....
	Oxford clay	73	.79	.38	1.88	.21
		34	.21	.38	.81	.55
		60	.91	.34	2.04	.47
		59	.53	.23	.59	.35
		52	.73	.33	1.70	.50
		53	.49	.32	.59	.25
		29	.34	.25	.60	.32
		4	.46	.45	2.99	.38

[*] In the original paper the results are expressed as lime carbonate and lime other than carbonate and have been recalculated to give CaO content.

Fifth annual Report on the Soils of Dorset, University College, Reading, 1903

Chemical composition of the soils of Great Britain and Ireland—Continued.

ENGLAND—Continued.

County.	Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Dorset	Cornbrash	10	0.26	0.49	3.16	0.64
		76	.50	.45	6.29	.22
		28	.22	29	6.88	.46
	Fullers earth	18	.41	.45	.99	1.06
		23	.17	.26	.77	.57
		56	.66	.27	.91	.35
		46	.89	.30	1.09	.53
		90	.80	.31	4.50	.53
		26	.53	.17	8.23	1.01
	Inferior oolite	91	.52	.64	4.80	.93
		13	.50	.37	11.60	.29
	Junction inferior oolite and Midford sands.	14	.31	.34	2.44	.60
	Midford sands	55	.38	.36	.77	.48
		54	.38	.25	.45	.44
		45	.44	.38	.58	.41
		5	.33	.49	.31	.39
		92	.26	.60	.42	.29
	Junction Midford sands and marlstone.	6	.21	.31	1.34	.41
		43	.57	.32	1.39	.10
	Marlstone	7	.36	.49	.59	.38
		70	.30	.63	.65	.02
		75	.76	.33	.80	.43
		78	.58	.47	2.44	.61
	Junction marlstone and lower Lias.	24	.27	.29	.72	.38
		44	.69	.35	.95	.39
	Lower Lias	17	.32	.40	2.28	.16
		74	.65	.51	1.14	.84
		93	.51	.53	.96	.55
Essex [a]	Birch	....	.38	.10	.57	....
	Buloau	....	.38	.10	.83	....
	Burnham	....	.17	.18	1.78	....
	Hedingham	....	.53	.16	1.18	....
	Gosfield	....	.14	.14 .24	.63	....
	Orsett	....	.12	.08	.36	....
	Ramsden	....	.15	.22	.92	....
	Roxwell	....	.79	.20	5.96	....
	Saffron Walden	....	.34	.11	3.85	....
		....	.41	.10	5.80	....
		....	.48	.09	7.75	....
	Tendring	....	.20	.16	.29	....
	Thaxted	....	.18	.13	.85	....
	St. Osyth	....	.16	.09	1.63	....
	Yeldham	....	.52	.15	1.64	....
Cambridge [b]	Hatley plot	3	.85	.39	.88	....
	Joint rotation	....	.64	.22	.90	....
	Burgoynes (Univ. farm):					
	Fields 11-13	....	.625	.083	2.20	....
	Fields 14-15	....	.559	.139	2.15	....
	Fields 16-17	....	.58	.22	.76	....
	Fields 18-19	....	.575	.091	.90	....
	Bowlder clay:					
	Above Gault	....	.948	.14	3.95	.285
	Above Green sand	....	.785	.113	.78	.28
	Above Gault	....	.994	.107	1.22	.35
	Above Grey chalk	....	.963	.102	1.325	.60
	Gault soils	....	1.14	.14	3.87	.29
			1.143	.127	7.28	.15
			1.13	.097	4.74	.215
	Kimeridge clay soils	....	1.13	.147	.425	.134
			1.00	.098	.515	.18
			1.58	.093	2.425	.155
	Ampthill clay soils	....	.655	.096	.48	.145

[a] Dymond, The Essex Field Experiments, 1896-1901, Part I. Compiled for the Essex Technical Instruction Committee.
Jour. Essex Tech. Laboratories, 3, 163 (1897).
Dymond and Bull, the Essex Field Experiments, 1896-1903, No. 2.
Dyer and Rosling, Rep. Field Expts., 1893-4, Essex Agricultural Society.
Guide to Experiments at Univ. Farm and other Centers in the Eastern Counties, Cambridge University, 1907.

[b] Guide to Experiments at University Farm and other Centers in the Eastern counties, Cambridge University, 1907.
Foreman, Journal Agricultural Science, 2, 161 (1907).

Chemical composition of the soils of Great Britain and Ireland—Continued.

ENGLAND—Continued.

County.	Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime. (CaO).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Cambridge	Oxford clay soils	....	1.06	0.118	0.323	0.215
			1.11	.145	.322	.47
			1.09	.138	.308	.25
	Lower green sand soils	....	.236	.204	.065	.08
			.278	.259	.085	.125
			.47	.197	.34	.24
			.443	.169	.26	.17
			.47	.146	.15	.14
Lincolnshire [a]	Peaty matter from the fens	....	....	.25	2.23	....
	Fen soil	I	.42	.26	1.44	.28
		II	.43	.21	1.50	.34
		III	.28	.16	1.02	.42
	Marsh soil	I	.16	.16	2.16	.40
		II	.20	.21	2.12	.28
	Farm near Crowland	I	.08	.77	1.20	.30
		II	.07	1.02	1.00	.50
		III	.08	1.24	.87	.13
		IV	.11	1.20	1.24	.21
		V	.08	.68	1.09	.39
		VI	.09	1.23	2.00	.40
Northumberland [b]	Wemonsti Farm plot	1	.283	.106	.306	....
		9	.244	.087	.265	....
	Miniature Farms	1	.04	.12	....	....
		2	.04	.11	....	....
		3	.04	.13	....	....
		4	.05	.13	....	....
		5	.04	.13	....	....
		6	.05	.12	....	....
	Hanging Leaves	....	.49	.06	.43	....
	Castle Steads	....	.31	.07	.25	....
	Davy Houses	....	.20	.08	.27	....
	East Tower Hill	....	.06	.17	....	....
	Peepy	....	.144 .114	.034	.48	....
	Whitefield	....	.072	.115	.45	....
	Kimblesworth	....	.27	.07	.33	....
	Rose Bank	....	.33	.05	.28	....
	Cockle Park:					
	Tower Hill	....	.80	.04	.31	....
	Back House	....	.263	.097	.286	....
	Tree Field	....	.50	.07	.60	....
	Pallace Leas Field plot	1	.36	.10	.44	....
		2	.40	.08	.44	....
		6	.33	.06	.39	....
		8	.28	.06	.37	....
		12	.39	.06	.55	....
		13	.30	.05	.42	....
Northampton [c]	Cransley plot	1	.54	.116	.60	....
		2	.57	.145	.67	....
		3	.59	.08	.53	....
		4	.66	.155	.62	....
		5	.50	.139	.45	....
		6	.54	.133	.58	....
		7	.49	.142	.79	....
		8	.50	.113	.45	....
		9	.65	.112	.84	....
		10	.65	.122	.76	....
Isle of Ely [d]	Black soils:					
	White Fen Benwick	....	.604	.306	2.95	....
	Little Port Fen	....	.559	.284	4.39	....
	Wryde	....	.458	.432	2.54	....
	Loam, Wisbeck Fen	....	.602	.383	3.54	....
	Clays, Wryde	....	.532	.264	.764	....
			1.276	.374	1.48	....
	Silts, Wryde	....	.392	.224	3.19	....

[a] E. W. Bell, Chemical News, 68, 191 (1893), used HCl (S. G. 1.16).
R. H. Wilson, Chemical News, 70, 153 (1894).

[b] Somerville Agricultural Experiments, 5 years' work at the Northumberland County Demonstration Farm, 1902, pp. 62 and 167.
Gilchrist, Bulletin 4, Armstrong College, Newcastle upon Tyne.
Ninth Annual Report on Experiments, Counties of Cumberland, Durham, and Northumberland, 1900.
Gilchrist, Bulletin 8, County Agricultural Experiment Station, Newcastle upon Tyne.

[c] Report on Experiments at Cransley, Northamptonshire in Seasons 1901, 1902, and 1903, Cambridge University.

[d] First Annual Report of Experiments, 1897, Cambridge, and Counties Agricultural Education Scheme.
Guide to Experiments at University Farm and other Centers in the Eastern Counties, Cambridge, 1907.

Chemical composition of the soils of Great Britain and Ireland—Continued.

ENGLAND—Continued.

County.	Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Isle of Ely	Silts, Needham [a]	....	0.281	0.245	1.58	....
			.288	.192	1.57	....
Cheshire [a]	....	1	.30	.10	.54	....
		2	.41	.30	.60	....
Norfolk [b]	Saxlingham	....	.09	.082	.47	....
	Stanhoe	....	.112	.057	1.39	....
	Trowse plot	3	.13	.16	1.43	....
Suffolk [c]	Bramford	....	.19	.18	2.18	0.27
	Saxmundham	....	.71	.248	1.59	....
Durham [d]	Grange Hill plot	10	.07	.13	....	....
	Shield Ash plot	1	.35	.09	.54	....
		11	.47	.13	.81	....
Cumberland [e]	Rose bank plot	1	.37	.05	.27	....
		11	.33	.05	.28	....
		24	.30	.05	.25	....
Hampshire [f]	Newlands Manor, Lymington.	....	.26	.17	.70	.46
	West Mark, near Petersfield.	....	.16	.145	.84	.29
Oxford [f]	Wick. Farm:					
	Headington, I	....	.049	Trace.	.45	.03
	Headington, II	....	.12	Trace.	5.49	.19
Berkshire [f]	Sutton's seed trial grounds, Reading.	....	.17	.37	.80	.10
					$CaCO_3$	
Wiltshire [g]	Christchurch, Allotment Station, Warminster.	....	.38	.34	4.17	.27
	Borham road, Warminster	....	.369	.258	.195	.21
			.31	.30	.165	.29
	Hormingsham	....	.366	.254	.125	.18
	Heytesbury	....	.42	.45	55.36	.13
	Codford allotment soil	....	.179	.466	12.21	....
	Chitterine allotment soils	....	.246	.908	47.50	....
	Imber allotment	1	.154	.370	42.35	....
		2	.259	.402	49.97	....
	Corsley plot	....	.459	.134	.60	....
	Clay soil, Warminster	....	.184	.255	25.55	....
	York warp soil	....	.308	.223	4.17	....
Kent [h]	London clay:					
	Whilstable	....	1.13	.119	.35	2.02
	Sheppey	....	1.44	.111	.224	1.24
	Chalk soils:					
	Wye	....	.345	.143	7.91	.193
	Minster, Thanet	....	.478	.101	1.96	.58
			.459	.094	3.70	.64
	Sutton-by-Dover	....	.432	.192	18.1	.69
	Neophan	....	.59	.126	12.2	.62
	Wye Court	....	....	.244	31.4	....
			....	.151	14.84	....
	Wye S. E. A. C.	....	....	.194	33.4	....
	Olantigh	....	....	.180	37.7	....
	Wye	....	....	.177	28.6	....
	Charing	....	.623	.217	30.9	....
	East Lenham	....	.64	.109	14.2	....
	Charing	....	.479	.132	.44	....
			1.07	.136	.99	....
	Gault soils:					
	Brook	....	.899	.133	2.52	.040
			.901	.253	.019	.072
	Westwell	....	.739	.084	.061	....
			....	.048	2.42	....
	Charing	....	....	.038	.20	....

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[a] Yearbook College of Agriculture and Horticulture, Holmes Chapel, Cheshire, 1904.

[b] Guide to Experiments at University Farm and other Centers in the Eastern Counties, Cambridge University, 1907.

[c] Report on Experiments at Bramford and Saxmundham.

[d] Sixth Annual Report on Experiments in Counties of Cumberland, Durham, and Northumberland, 1897.

Tenth Annual Report on Experiments in Counties of Cumberland, Durham, and Northumberland, 1901.

[e] Tenth Annual Report on Experiments in Cumberland, Durham, and Northumberland.

[f] Gilchrist and Foulkes, Suppl. I, Jour. Extension College, Reading, 1896.

[g] Report on Experiments, Wilts County Council, 1892, 1893, 1895.

[h] Hall and Plyman, First Report on Chemical and Physical Study of the Soils of Kent and Surrey, 1902.

Chemical composition of the soils of Great Britain and Ireland—Continued.

ENGLAND—Continued.

County.	Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime. (CaO).	Magnesia (MgO).
Kent	Gault soils:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
	East Lenham		0.837	0.12	013.2	
	Brook		.915	.16	.022	
			1.01	.131	1.76	
	East Lenham		.64	.199	10.6	
	Hothfield		.515	.132	.85	
Surrey[a]	London clay:					
	Wanborough Station		.329	.065	.65	.35
	Ashtead Common		.76	.093	.002	1.12
	Wyke		.36	.061	.24	
	Flexford		.478	.066	2.4	
	Stoughton			.053	.057	
	Wanborough		.493	.078	.03	
	Raynes Park		.67	.097	.073	
	Horsley		.45	.116	.19	
	Chalk soils:					
	Seale		0.236	0.18	56.9	0.40
	Fetcham		.298	.193	39.0	2.81
	Puttenham			.166	53.6	
	Wanborough			.163	61.4	
	Sutton		.265	.138	6.98	
	Gault soils, Alderholt		.068	.092	.040	.009
				.151	.025	
				.074	.039	
			.394	.0895	.024	

WALES.[b]

					CaO.	
	Garden soil		0.142	0.306	1.40	0.671

SCOTLAND.[c]

					$CaCO_3$.	
	Cleghorn, near Lanark, plots 1		0.187	0.104	0.44	
	2		.116	.126	.32	
					CaO.	
	Drumford, Helensburgh		.237	.45	0.168	
	Easterboard, Croy		.213	.128	.403	
	Birgidale Knock, Rothesay		.928	.244	.638	
	Tarves		.539	.481	.594	
	Wester Fintray, Kintore		.244	.283	.593	
	Fedderate, Maud		.247	.367	.568	
	Telloch, Lumphanan		.279	.113	.826	
	Fasque, Fettercairn		.463	.214	.759	

IRELAND.[d]

Cork	Limestone soils, Shanagany	0.464	0.148	3.938	
	Old red sandstone, Killeagh	.547	.156	.201	
Wexford	Silurian clay slate soils:				
	Bally Carney	.384	.156	.268	
	Clonroche	.720	.167	.301	
Tipperary	Limestone soils:				
	Rockford	.846	.16	1.568	
	St. Kieran's	.943	.13	1.266	

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[a] Hall and Plyman, First Report on Chemical and Physical Study of the Soils of Kent and Surrey, 1902.

[b] Annual Report Field Experiments, University College of Wales.

[c] Reports on Experiments, 1893, Glasgow and West of Scotland Technical College.
Reports on Experiments, 1895, Glasgow and West of Scotland Technical College.
Reports on Experiments, 1903 and 1904, Aberdeen and North of Scotland College of Agriculture.

[d] H. C. Sheringham. 1st Annual Report of Field Experiments in Counties of Wexford, Cork, Tipperary, Mayo, Meath, King's and Queen's, 1898.

Chemical composition of the soils of France.

AISNE.[*]

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
LAON.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Semilly	1	0.36	0.09	11.22	0.007
	4	.60	.11	5.07	.003
	6	.22	.07	.52	.004
Chambry	1	.20	.18	5.44	.004
	3	.21	.09	7.45	.01
	5	.27	.13	34.12	.01
	7	.28	.14	15.55	.004
	8	.08	.03	.92	.005
	10	.28	.06	.86	.006
Bugy-les-Cerny	1	.44	.16	1.76	.01
	3	.41	.07	3.36	.006
	5	.57	.06	1.22	.01
Crepy-en-Laon-nois	1	.28	.06	.96	.05
	3	.08	.02	2.83	.02
	7	.22	.07	34.53	.01
	9	.16	.06	.60	.01
	11	.24	.08	.32	.005
	14	.25	.10	2.40	.01
	16	.19	.12	7.64	.01
	17	.27	.10	58	.01
Vorges	1	.20	.24	5.56	.01
	3	.20	.08	1.04	.005
	5	.22	.08	.60	.01
	7	.33	.10	1.98	.004
	8	.06	.06	59.50	.01
	9	.48	.06	9.36	.01
Presles	1	.38	.06	3.71	.03
	3	.12	.04	3.52	.005
	5	.30	.05	.15	.005
Montberault	1	.37	.08	64.75	.02
	3	.20	.06	2.43	.01
	5	.47	.10	1.10	.06
	8	.07	.04	.18	.005
	11	.42	.11	10.40	.16
	13	.32	.05	4.69	.005
	15	.29	.08	.71	.04
Chevregny	1	.16	.02	.64	.02
	3	.47	.07	2.24	.02
	5	.16	.08	.64	.01
	7	.28	.07	.96	.01
	8	.26	.03	29.20	.01
	9	.21	.07	7.80	.004
	11	.52	.03	.76	.01
	13	.70	.26	7.08	.02
	15	.71	.10	37.00	.005
Urcel	1	.10	.03	.09	.01
	3	.22	.09	4.64	.18
	6	.25	.05	.17	.003
	7	.30	.09	1.12	.015
	9	.12	.04	31.31	.005
Quincy-Basse	1	.10	.06	1.06	.005
	3	.26	.07	2.68	.05
	5	.16	.08	.88	.02
Landricourt	1	.10	.08	1.06	.005
	3	.26	.07	2.68	.06
	6	.30	.08	.48	.02
	8	.30	.06	.92	.01
	10	.39	.10	1.72	.02
Jumencourt	1	.18	.08	9.20	.006
	2	.57	.06	.76	.27
	4	.18	.08	39.70	.01
Folembray	1	.25	.03	1.60	.01
	3	.12	.04	.08	.02
	5	.22	.03	2.93	.06
	7	.15	.03	.32	.003
	8	.11	.04	1.70	.02
	10	.15	.05	.50	.01
Leuilly-sous Coucy	1	.22	.09	1.76	.006
	3	.24	.10	2.00	.003
	4	.26	.06	.52	.005
	7	.23	.05	.37	.003
Crecy-au-Mont	1	.23	.12	4.94	.01
	3	.27	.07	.28	.01
	5	.29	.11	.68	.02

[*] Bulletins Sta. Agron. Dep. de l'Aisne, 1891, 1892, 1893, 1894.

Chemical composition of the soils of France—Continued.

AISNE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5)	Lime ($CaCO_3$).	Magnesia (MgO).
LAON—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Crecy-au-Mont	7	0.25	0.08	0.64	0.29
	9	.19	.06	51.20	.01
	11	.47	.09	7.98	.01
	13	.50	.07	.72	.02
	15	.15	.04	2.30	.01
Pont-Saint Mard	1	.18	.06	.24	.008
	3	.25	.08	.52	.006
	5	.26	.08	32.30	.01
	7	.30	.03	.17	.008
	9	.26	.06	.84	.006
Vaudesson	3	.17	.06	.72	.02
	5	.21	.08	17.08	.01
	6	.28	.10	.18	.02
	8	.19	.06	.41	.01
	10	.33	.08	.18	.004
	12	.25	.05	1.00	.47
Couvrelles	1	.55	.13	2.12	.006
	5	.18	.02	81.20	.008
	7	.27	.06	.40	.008
	9	.39	.03	3.23	.006
	11	.26	.04	.15	.02
	13	.38	.09	.79	.07
	15	.31	.09	.86	.08
Mercin	1	.20	.09	.72	.01
	3	.22	.11	.73	.01
	7	.28	.06	1.00	.01
	9	.23	.04	.36	.004
	11	.22	.04	3.14	.04
	13	.08	.13	.55	.01
Amifontaine	1	.24	.24	7.08	.004
	3	.19	.15	13.21	.006
	4	.13	.09	10.60	.07
	5	.30	.19	33.92	.008
	6	.15	.19	10.46	.006
	7	.45	.13	38.70	.006
	8	.18	.06	9.24	.01
	10	.29	.16	63.80	.07
	11	.26	.09	14.40	.07
Juvincourt	1	.23	.09	13.12	.08
	2	.14	.07	1.34	.01
	4	.28	.11	26.50	12
Berry-au-Bac	1	.37	.16	49.20	.08
	2	.32	.21	25.00	.08
	4	.30	.12	23.60	.04
Gernicourt	1	.20	.10	4.82	.01
	2	.09	.02	.68	.006
	4	.14	.03	9.90	.008
	6	.27	27	80.70	.06
	7	.17	07	75.90	.01
Clérmont-les-Ferme.s	1	.25	.10	.57	.02
	3	.37	17	[illegible]	.01
	5	.20	.11	1.28	.008
	7	.30	.12	1.19	.008
	9	.31	.08	.98	.008
	11	.35	10	45	.008
	13	.25	.08	.36	04
	15	.21	.09	16	.006
	17	.43	.10	.80	.004
Missy-les-Pierrepont	1	19	.06	.29	.008
	3	.27	.15	2.24	.008
	4	.40	.07	2.06	07
	6	.29	.06	.28	05
	8	.28	.09	.70	02
Grandlup	1	.35	.13	0.94	01
	2	.21	.08	2.20	01
	3	.24	.06	.28	01
	5	.40	.14	1.63	01
	7	.38	.14	3.08	01
	8	.15	.09	1.03	01
Frieres-Faillouel	1	19	.08	1.70	.008
	3	.29	.09	5.16	01
	5	.30	.07	.38	[illegible]
	9	.35	.09	5.46	.008
	10	.33	07	2.32	01

Chemical composition of the soils of France—Continued.

AISNE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
LAON—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Liez	1	0.25	0.11	3.06	0.005
	4	.32	.07	5.24	.01
	6	.22	.08	3.18	.004
	8	.18	.11	39.50	.01
	10	.20	.11	1.05	.005
	12	.18	.20	.36	.01
	14	.24	.08	1.33	.01
Charmes	1	.47	.11	.58	.003
	3	.25	.07	2.62	.02
	5	.58	.13	5.28	.004
	7	.15	.09	1.56	.004
	9	.27	.09	1.60	.01
	12	.85	.12	7.04	.01
Rogecourt	1	.28	.10	3.08	.05
	3	.13	.08	2.03	.07
	5	.24	.08	3.14	.01
	8	.28	.09	1.13	.006
	9	.23	.04	3.68	.02
Fressancourt	1	.28	.08	.52	.02
	3	.29	.08	1.96	.05
	5	.26	.10	2.32	.008
	7	.28	.10	5.84	.005
Faucouzy	1	.31	.10	4.50	.04
	4	.37	.15	3.40	.05
	5	.32	.20	65.50	.003
	6	.34	.09	.72	.04
	8	.60	.18	28.80	.004
	10	.22	.11	2.40	.08
	12	.30	.14	19.70	.02
	14	.35	.87	62.00	.01
Chevresis-Monceau	1	.28	.10	5.10	.01
	3	.22	.10	33.88	.005
	5	.08	.05	35.08	.01
	7	.25	.10	15.65	.004
	9	.05	.10	48.30	.004
Grugies	1	.34	.08	.25	.01
	4	.35	.14	4.76	.01
	6	.46	.06	8.22	.005
	8	.27	.04	41.44	.005
	9	.24	.08	.46	.005
Cressancy	1	.20	.06	34.20	.02
	5	.29	.03	.54	.01
	7	.47	.10	8.26	.02
	11	.33	.09	10.20	.01
Epieds	1	.21	.07	1.15	.006
	3	.26	.06	.28	.01
	6	.27	.06	.78	.02
	9	.48	.07	16.98	.01
	11	.21	.08	.68	.02
	13	.19	.05	1.50	.02
Torcy	1	.19	.05	.68	.006
	3	.09	.04	1.28	.006
	5	.18	.06	8.91	.04
	7	.20	.08	3.30	.08
	9	.20	.05	.61	.01
	11	.35	.06	.98	.02
Pouilly-sur-Serre	1	.23	.15	2.19	.004
	3	.35	.04	.45	.003
	5	.25	.04	5.24	.005
	7	.32	.04	.34	.005
	9	.30	.23	8.00	.004
	10	.30	.06	33.93	.005
	13	.65	.05	3.25	.003
Mouvion et Catillon	1	.33	.03	.80	.006
	2	.39	.10	.50	.003
	5	.43	.05	1.70	.01
	6	.42	.11	1.42	.005
	8	.30	.08	.48	.008
	10	.30	.09	.70	.005
	12	.37	.07	1.28	.01
	13	.25	.07	.48	.01
	15	.26	.12	53.20	.005
Mesbrecourt-Richecourt	1	.35	.11	4.20	.006
	2	.37	.14	.26	.003

Chemical composition of the soils of France—Continued.

AISNE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
LAON—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Mesbrecourt-Richecourt	5	0.58	0.08	0.39	0.01
	7	.32	.13	1.18	.0
	9	.26	.11	49.00	.0
	10	.46	.05	1.30	.0
	12	.44	.11	1.24	.0
	14	.51	.10	.39	.0
	16	.27	.12	1.16	.0
La Ferte-Chevresis	1	.34	.08	2.58	.0
	3	.46	.11	1.16	.0
	5	.38	.13	.74	.0
	7	.30	.11	28.44	.0
	8	.37	.19	45.16	.0
	9	.31	.12	1.95	.0
	11	.69	.16	.67	.0
	13	.32	.11	9.98	.0
Valecourt	1	.33	.20	56.45	.0
	2	.57	.06	2.60	.0
	5	.39	.07	3.94	.0
	7	.37	.10	.66	.0
	10	.32	.08	36.80	.0
	11	.37	.09	1.24	.0
Pargny-les-Bois	1	.32	.04	.30	.0
	3	.13	.13	62.00	.0
	6	.42	.10	1.06	.0
Bois-les-Pargny	1	.33	.05	.28	.0
	3	.46	.08	.84	.0
	5	.21	.09	.38	.0
	7	.34	.07	.64	.0
Erlon	1	.14	.08	1.36	.0
	3	.29	.08	.52	.0
	5	.28	.09	.46	.0
	7	.30	.07	.37	.0
	9	.24	.05	.70	.0
	11	.15	.14	62.45	.0
Marcy	1	.20	.04	.32	.0
	3	.30	.15	37.00	.0
	5	.38	.12	.60	.1
	7	.27	.05	.41	.0
Vayenne	1	.23	.06	.68	.0
	3	.37	.13	.18	.0
	5	.31	.12	7.88	.0
	7	.27	.14	15.53	.0
	9	.28	.18	7.96	.0
Marle	1	.42	.16	.85	.0
	3	.31	.07	1.00	.0
	5	.41	.09	.70	.0
	7	.23	.07	.80	.0
	9	.47	.14	.80	.0
Houry	1	.42	.09	1.18	.0
	3	.50	.18	1.44	.0
	6	.27	.10	1.65	.0
	8	.48	.13	2.96	.0
	10	.35	.09	4.78	.0
Prisces	1	.61	.15	.76	.0
	3	.30	.16	1.47	.0
	5	.53	.23	.64	.0
	7	.34	.13	1.30	.0
	9	1.30	.80	.70	.0
Gronard	1	.33	.08	1.04	.0
	4	.26	.07	.56	.0
	6	.28	.03	1.84	.0
Agnicourt et Sechelles	1	.28	.11	3.00	.0
	3	.28	.26	8.08	.0
	5	.30	.10	1.18	.0
	7	.26	.18	2.55	.0
	9	.25	.25	53.50	.0
	10	.51	.15	.68	.0
	12	.30	.10	.32	.0
	14	.21	.17	67.00	.0
Montlous	1	.23	.07	.32	.0
	3	.28	.09	.68	.0
	5	.45	.08	.78	.0
	7	.21	.15	56.00	.0
	9	.35	.17	1.08	.0

Chemical composition of the soils of France—Continued.

AISNE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
LAON—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Noircourt	1	0.[illegible]3	0.06	5.88	0.01
	3	.50	.08	.36	.006
	5	.29	.06	3.55	.02
	7	.41	.11	13.50	.003
	11	.15	.16	38.00	.006
	12	.40	.08	.98	.01
	14	.14	.10	1.97	.02
	16	.14	.06	1.36	.03
	18	.35	.06	.48	.01
Goudelancourt	1	.39	.18	26.50	.004
	3	.23	.07	.50	.005
	5	.41	.10	.72	.01
Ebouleau	1	.52	.08	.25	.004
	3	.39	.07	.40	.004
	5	.25	.09	.14	.007
	7	.28	.05	42.00	.007
Bucy-les-Pierrepont	1	.16	.06	.14	.003
	3	.24	.08	29.50	.004
	5	.20	.07	.52	.02
	7	.44	.08	.42	.01
	9	.39	.07	.34	.003
	11	.40	.06	.44	.01
	13	.27	.02	.12	.004
	15	.37	.08	.72	.01
Boncourt	1	.25	.09	.28	.12
	3	.29	.07	.26	.03
	5	.28	.10	.48	.01
	7	.28	.08	.80	.11
Lappion	1	.30	.11	47.00	.02
	3	.14	.04	.22	.01
	5	.23	.04	.12	.02
	6	.26	.05	.28	.02
	8	20	.07	.24	.02
	10	.28	.15	94.70	.19
	13	.37	.04	.64	.03
La Selve	1	.32	.04	1.84	.02
	2	.14	.08	48.00	.007
	3	.26	.07	.78	.02
Sissonne	1	.24	.21	43.00	.005
	3	.33	.07	9.20	.004
	4	.24	.09	.80	.004
	5	.24	.13	23.22	.003
	6	.28	.15	45.64	.007
	7	.30	.50	16.19	.003
	8	.49	.32	10.71	.005
	9	.14	.06	.52	.004
	10	.12	.04	.24	.004
Machecourt	1	.29	.12	49.00	.009
	3	.35	.03	.80	.006
	5	.39	.11	1.40	.002
	7	.44	.06	1.96	.01
Chivres	1	.47	.17	20.00	.004
	3	.24	.14	46.60	.003
	4	.23	.05	.24	.01
	6	.41	.19	5.64	.23
Liesse	1	27	.04	1.63	.004
Gizy	1	.20	.03	.52	.009
	3	.47	.04	.38	.007
	5	.30	.05	.20	.01
	7	.27	.09	.68	.02
Samoussy	1	.37	.06	.24	.008
	4	.27	.14	39.75	.01
	6	.24	.10	2.60	.01
	8	.23	.17	26.00	.02
Manceau-le-Waast	1	.25	.08	2.97	.01
	3	.19	.14	3.25	.03
Athies	1	.38	.12	.52	.01
	2	.40	.06	.28	.01
	4	.23	.09	1.00	.004
	6	.22	.07	.80	.007
	8	.29	.06	14.00	.006
	9	.27	.03	64	.004
Eppes	1	.31	.09	86.00	.006
	2	.30	.06	8.00	.008

Chemical composition of the soils of France—Continued.

AISNE—Continued.

Description and locality.	Original sample No.	Potash (K$_2$O).	Phosphoric acid (P$_2$O$_5$).	Lime (CaCO$_3$).	Magnesia (MgO).
LAON—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Coucy-les-Eppes	1	0.16	0.04	0.30	0.005
	3	.45	.08	.42	.004
	5	.19	.07	.36	.01
	6	.21	.03	.30	.001
	8	.47	.17	7.30	.01
	9	.29	.09	35.50	.003
	10	.25	.09	2.10	.003
Festieux	1	.16	.03	.16	.004
	3	.25	.07	10.50	.006
	4	.29	.13	25.44	.006
	5	.50	.08	1.50	.007
Veslud	1	.19	.04	.24	.003
	3	.18	.03	.04	.03
	4	.33	.05	.88	.004
	6	.35	.13	20.00	.01
Parfondru	1	.32	.10	.16	.007
	2	.52	.15	2.88	.01
	5	.26	.05	5.40	.02
Bruyeres	1	.14	.05	.24	.02
Arrancy	1	.32	.07	1.00	.008
	3	.27	.03	.84	.007
	5	.21	.05	10.88	.006
Ployart	1	.24	.11	.63	.007
	3	.44	.06	3.37	.03
	5	.18	.10	2.40	.01
Vauresseine	1	.37	.09	20.00	.007
	3	.33	.06	10.00	.02
	5	.24	.12	.40	.008
Montchalons	1	.40	.16	.60	.008
	3	.32	.10	3.40	.006
	5	.32	.04	.20	.005
Cheret	1	.36	.07	47.00	.02
	2	.36	.07	10.00	.02
Orgeval	1	.25	.06	1.40	.007
	4	.27	.14	.84	.004
Bievres	1	.26	.10	.44	.03
	3	.36	.17	20.00	.01
	4	.28	.10	11.00	.008
Martigny	1	.36	.07	1.10	.007
	3	.33	.07	13.06	.05
	4	.39	.12	13.18	.31
	5	.40	.07	.46	.06
Monampteuil	1	.20	.07	.99	.002
	3	.27	.05	.19	.006
	5	.20	.07	.23	.004
	7	.19	.07	.24	.005
	9	.34	.07	.45	.006
Braisne	1	.23	.67	.50	.03
	3	.28	.06	.48	.02
	5	.20	.05	.84	.03
	7	.17	.12	7.00	.01
Brenelle	1	.35	.04	.48	.01
Courcelles	1	.34	.05	.78	.01
	3	.47	.08	1.66	.03
	5	.24	.08	1.26	.08
	7	.28	.05	65.00	.01
	8	.16	.04	27.00	.01
	10	.20	.07	.44	.01
Lime	1	.32	.05	.74	.02
	3	.23	.05	.26	.01
	5	.31	.07	.42	.01
	7	.64	.07	.70	.01
	9	.32	.91	29.00	.01
Quincy-sous-Le-Mont et Bruyeres	2	.26	.05	.30	.02
	4	.27	.06	.41	.006
	6	.24	.06	.56	.01
	8	.22	.05	.58	.01
Laffaux	1	.24	.05	1.09	.008
	3	.37	.07	1.90	.008
	5	.22	.06	.52	.007
Neuville-sur-Margival	1	.42	.07	.48	.01
	3	.29	.06	.30	.006
Terny-Sorny	1	.36	.06	1.42	.006
	3	.39	.12	21.20	.008
	5	.38	.06	1.22	.003
	7	.26	.06	.42	.004
	9	.30	.07	.72	.02

Chemical composition of the soils of France—Continued.

AISNE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
LAON—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Margival	1	0.28	0.06	3.68	0.01
	3	.48	.08	2.02	.01
	5	.28	.08	.82	.005
	7	.28	.05	81.00	.003
	9	.26	.06	3.68	.005
Vuillery et Braye-sous-Clamecy	1	.28	.07	.34	.008
Villemontoire	1	.24	.13	5.10	.02
	3	.29	.09	.72	.01
	5	.16	.07	18.20	.03
	7	.20	.09	.82	.03
	9	.16	.08	.60	.007
Buzancy	1	.27	.04	.98	.01
	3	.33	.06	1.70	.01
	5	.31	.06	.40	.006
	8	.31	.07	3.41	.03
Aconin	1	.33	.08	9.70	.01
	3	.30	.09	1.10	.01
	4	.32	.06	.86	.02
	6	.37	.16	.40	.006
Cutry	1	.3	.05	.10	.005
	3	.38	.07	.24	.01
	5	.66	.07	1.88	.01
	7	.38	.06	.48	.004
Cœuvres et Valsery	1	.38	.08	.20	.01
	3	.24	.06	.24	.006
	5	.26	.07	54.00	.01
	6	.34	.12	2.24	.008
	7	.37	.08	.36	.01
Saint-Pierre-Aigle	1	.29	.03	.48	.007
	3	.25	.07	.24	.01
Laversiene	1	.33	2.02	.28	.005
	3	.31	.08	.28	.01
Dommiers	1	.31	.06	.20	.01
	3	.37	.10	.36	.05
Berny-Riviere	1	.8	.12	41.90	.003
	2	.80	.14	17.00	.003
Nouvron	1	.57	.08	.73	.01
	3	.64	.09	.65	.01
	5	.32	.06	.45	.003
	7	.42	.06	5.09	.02
	8	.14	.01	86.70	.004
Morsain	1	.30	.05	2.16	.007
	2	.18	.07	.70	.005
	3	.22	.06	2.23	.005
	5	.20	.05	5.44	.01
Vezaponin	2	.30	.05	33.04	.01
	4	.50	.03	.50	.01
	6	.44	.05	.30	.01
Selens	1	.29	.28	1.48	.01
	4	.12	.06	44.00	.01
	5	.39	.06	3.00	.03
	8	.35	.08	.61	.01
	10	.26	.04	1.18	.03
Saint-Aubin	1	.26	.06	1.08	.05
	3	.15	.05	2.80	.06
Trosly-Loire	1	.24	.06	2.27	.04
	3	.16	.06	.68	.05
	4	.19	.08	1.52	.06
	5	.17	.07	.82	.06
	7	.22	.03	9.96	.06
	8	.17	.09	2.08	.05
	9	.22	.07	.78	.03
Villequier-Aumont	1	.32	.05	.68	.01
	4	.57	.32	.38	.004
	6	.26	.08	.38	.008
	8	.26	.05	.82	.01
	10	.28	.05	.38	.01
Landouzy-la-Cour	2	.27	.11	2.30	.01
	4	.32	.06	.64	.01
	6	.35	.10	.38	.01
	10	.23	.09	.10	.01
	12	.34	.08	.20	.007
	14	.39	.08	1.00	.006
Vervins	1	.27	.11	.32	.01
	3	.24	.10	.20	.007
	5	.36	.10	1.28	.01
Fontaine-les-Vervins	1	.28	.11	.60	.08
	3	.30	.10	93.00	.007

Chemical composition of the soils of France--Continued.

AISNE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
LAON—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Fontaine-les-Vervins	4	0.33	0.10	0.68	0.009
	6	.32	.07	2.20	.006
	8	.40	.10	1.84	.007
Laigny	1	.29	.04	.44	.001
	3	.30	.10	.80	.006
	6	.30	.11	9.44	.01
Haution	1	.31	.08	1.24	.006
	3	.26	.09	.32	.007
Voulpaix	1	.31	.09	.56	.003
	2	.66	.07	.36	.007
	3	.24	.08	1.24	.01
	5	.28	.09	.88	.008
Marfontaine	1	.31	.17	1.96	.01
	2	.24	.06	.36	.01
	4	.28	.09	.52	.004
Rougeries	1	.33	.09	.92	.006
Presles	1	.25	.05	.35	.01
Nouvion	1	.47	.10	1.68	.006
	4	.30	.05	.15	.006
Laval	3	.27	.10	.56	.006
	6	.12	.06	.60	.02
Monthenault	1	.54	.07	.52	.005
	3	.46	.07	.16	.005
	5	.40	.04	.72	.004
	7	.40	.06	.06	.004
	8	.35	.04	1.64	.005
Chamouille	1	.32	.10	2.56	.05
	2	.38	.08	6.60	.006
Courtecon	1	.27	.06	.36	.006
	3	.26	.06	.70	.02
	5	.26	.06	.48	.003
	7	.37	.17	.96	.007
	10	.33	.08	11.[illegible]0	.03
Pancy	1	.24	.02	.20	.007
	3	.52	.09	.52	.01
Colligis	1	.52	.07	.84	.01
	3	.58	.05	9.96	.007
Grandelain	1	.28	.05	.24	.007
	4	.29	.07	.22	.01
	6	.33	.05	.18	.005
Trucy	1	.36	.07	.28	.003
	3	.33	.03	.20	.004
Lierval	1	.32	.06	19.86	.22
	2	.56	.12	8.52	.01
Leadins	1	.34	.14	.44	.01
	3	.30	.16	56.40	.004
	5	.39	.08	2.80	.02
	7	.38	.13	1.44	.01
Levergies	1	.27	.10	18.04	.02
	4	.27	.07	2.04	.02
	6	.36	.09	.92	.01
	8	.37	.10	.54	.01
Guoy	1	.39	.07	3.70	.01
	3	.59	.14	.76	.006
	5	.40	.12	.76	.01
	7	.17	.12	42.40	.01
	8	.51	.12	1.08	.008
	10	.50	.10	.60	.01
	12	.51	.09	1.76	.004
	14	.44	.09	11.92	.01
	16	.38	.10	.64	.01
Prouvais	1	.22	.08	.68	.007
	3	.29	.06	2.80	.02
	6	.40	.22	32.70	.01
	7	.21	.24	34.00	.01
	9	.46	.30	52.00	.02
	10	.22	.15	7.44	.01
Molinchart	1	.36	.09	3.40	.01
	3	.27	.04	.32	.005
Clacy	5	.38	.09	44.50	.01
Merlieux	1	.30	.11	6.40	.02
	2	.32	.23	2.06	.03

Chemical composition of the soils of France—Continued.

AISNE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
LAON—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Merlieux	3	0.38	0.06	0.16	0.003
	5	.32	.04	.16	.003
Montbavin et Montarsene	1	.37	.07	.62	.01
	3	.26	.05	.76	.01
	5	.19	.04	.40	.01
	7	.23	.04	.12	.01
	8	.28	.05	.22	.01
	9	.20	.08	27.00	.02
Barisis	1	.22	.06	.64	.007
	3	.38	.08	1.00	.004
	6	.23	.06	22.00	.005
	7	.29	.05	1.08	.003
Mont-Saint-Martin	1	.42	.09	6.70	.02
	3	.39	.10	1.04	.007
	5	.36	.09	15.60	.01
	8	.45	.06	.48	.01
Nesles	1	.23	.06	.48	.02
	3	.38	.06	.28	.004
	5	.29	.06	.20	.005
	7	.26	.05	.60	.003
	9	.28	.10	.80	.01
Nogentel	3	.24	.06	32.00	.02
	4	.40	.23	5.80	.01
Etampes	1	.72	.09	1.36	.04
	2	.24	.12	7.50	.005
Chierry	1	.29	.15	15.92	.03
	3	.40	.20	20.00	.01
Fossoy	1	.77	.08	17.46	.03
	3	.17	.12	13.74	.006
	5	.33	.06	14.96	.02
Seraucourt-Le-Grand	1	.28	.14	3.53	.02
	8	.29	.06	.10	.02
	5	.50	.09	1.08	.01
	7	.28	.21	3.24	.007
Happencourt	1	.44	.15	3.23	.008
	3	.42	.22	31.00	.02
	5	.38	.10	8.64	.01
Artemps	1	.47	.13	2.98	.01
	3	.30	.10	1.56	.01
Clastres	1	.32	.05	.60	.005
Guise	1	.29	.08	.20	.02
	4	.64	.11	2.64	.03
	6	.40	.09	.70	.007
	8	.39	.03	.24	.003
Lesquielles-Saint-Germain	1	.27	.56	45.00	.01
	2	.46	.07	.72	.01
	4	.36	.12	3.04	.01
	6	.31	.10	.00	.003
Vieil Arcy	1	.36	.07	1.40	.003
	3	.14	.07	.40	.002
	5	.25	.07	16.00	.002
	7	.14	.10	3.16	.003
	10	.47	.25	13.60	.002
Dhuizel	1	.39	.07	.60	.004
	3	.25	.07	.76	.003
Longpont	1	.65	.16	1.00	.002
	2	.30	.07	.92	.004
	4	.35	.11	1.10	.005
	6	.43	.06	1.00	.004
	9	.34	.09	16.80	.002
Couvron	1	.31	.16	4.06	.04
	3	.34	.12	5.88	.03
	4	.17	.18	58.00	.02
	5	.21	.07	.20	.04
Barenton-Cel	1	.51	.10	2.62	.01
	3	.35	.09	8.70	.02
	4	.39	.09	1.62	.007
	6	.14	.19	72.00	.006
	8	.51	.08	.60	.003
	10	.41	.07	14.00	.009
Chalandry	1	.49	.09	1.80	.004
	3	.32	.12	2.10	.01

Chemical composition of the soils of France—Continued.

AISNE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
LAON—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Cessieres	1	0.23	0.12	0.56	0.003
	3	.33	.06	.36	.002
	5	.45	.05	.52	.02
	5	.34	.07	.36	.002
Guivry	2	.27	.07	.40	.003
	4	.24	.08	.48	.004
	8	.33	.09	.72	.004
Beriancourt	1	.38	.08	1.20	.02
	3	.43	.09	2.20	.06
	5	.27	.09	5.50	.01
	7	.23	.11	16.00	.006
	8	.36	.09	2.68	.02
Neuville-Saint Amand	1	.41	.08	.20	.005
	3	.49	.12	2.00	.009
	5	.43	.03	2.16	.005
	7	.45	.16	47.00	.007
	8	.33	.07	3.02	.006
	10	.35	.07	1.40	.006
	12	.40	.09	1.60	.008
	15	.53	.18	1.00	.005
Remaucourt	1	.38	.16	3.36	.01
	3	.47	.13	1.62	.01
	6	.37	.12	2.52	.01
	9	.34	.22	39.50	.01
Vauxresis	1	.34	.07	.64	.002
Cuisy en Almont	1	.41	.09	.24	.004
	3	.31	.07	1.08	.002

PAS-DE-CALAIS.[a]

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
Erquieres	1	0.268	0.119	0.405	....
	2	.137	.092	2.411	....
	3	.267	.098	1.836	....
	4	.267	.103	3.875	....
	5	.298	.211	15.565	....
	6	.219	.172	57.344	....
Guigny	1	.32	.143	1.652	....
	2	.35	.086	1.932	....
	3	.30	.104	1.897	....
	4	.289	.159	8.112	....
	5	.317	.121	35.971	....
Berthonval	1	.26	.10	1.17	....
	2	.33	.14	1.51	....
	3	.30	.115	.20	....
	4	.29	.22	23.39	....
	5	.34	.094	.925	....
Loues	1	.316	.116	.70	....
	2	.293	.118	1.20	....
	3	.388	.158	4.215	....
	4	.333	.19	4.265	....
	5	.319	.26	23.00	....
	6	.328	.252	23.00	....
Valhuon	1	.376	.096	1.12	....
	2	.314	.094	.716	....
	3	.245	.092	1.36	....
	4	.219	.094	1.05	....
	5	.266	.084	1.19	....
Saint Martin	1	.121	.108	.135	....
	2	.176	.156	1.085	....
	3	.154	.15	.625	....
	4	.176	.156	2.70	....
	5	.169	.146	.475	....
	6	.185	.156	1.35	....
	1	.191	.159	.533	....
	2	.196	.133	4.906	....
	3	.249	.121	1.183	....
	4	.248	.145	2.786	....
	5	.289	.158	1.848	....
	6	.30	.086	.648	....
	7	.198	.142	1.041	....
	8	.174	.098	1.041	....

[a] Terres Arables de Pas-de-Calais, Pagnoul, 1894. Bulletin Station Agronomique Pas-de-Calais, 1895.

Chemical composition of the soils of France—Continued.

PAS-DE-CALAIS—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Marck	1	0.33	0.116	18.011	....
	2	.256	.063	14.016	....
	3	.347	.129	25.145	....
	4	.25	.092	22.086	....
	5	.043	.031	.101	....
	6	.25	.116	14.974	....
Offekerque	1	.384	.104	16.412	....
	2	.29	.101	14.101	....
	3	.22	.092	13.834	....
	4	.291	.105	15.806	....
Guines	1	.235	.153	.96	....
	2	.282	.167	7.693	....
	3	.248	.254	21.334	....
	4	.324	.224	13.014	....
Faubourg Ronville	1	.26	.704	38.75	....
	2	.223	.702	34.427	....
	3	.257	.554	19.739	....
	4	.295	.40	4.572	....
	5	.258	.194	1.625	....
	6	.266	.642	9.639	....
Souastre	1	.268	.092	1.84	....
	2	.241	.091	1.47	....
	3	.277	.11	.518	....
	4	.267	.075	1.504	....
	5	.239	.09	2.053	....
	6	.29	.08	2.21	....
	7	.249	.092	2.596	....
Pas	1	.262	.08	1.02	....
	2	.208	.134	3.866	....
	3	.311	.081	3.112	....
	4	.345	.08[illegible]	.97	....
	5	.245	.28	.923	....
	6	.256	.056	.031	....
	7	.177	.25	62.448	....
	8	.199	.104	1.62	....
	9	.31	.10	2.72	....
Serres	1	.278	.123	.961	....
	2	.122	.143	.468	....
	3	.30	.118	4.17	....
	4	.255	.106	.75	....
	5	.315	.114	1.62	....
	6	.263	.107	2.02	....
	7	.268	.11	1.11	....
Fresnes-lez-Montauban	1	.277	.162	3[illegible].272	....
	2	.36	.11	1.972	....
	3	.257	.085	1.901	....
	4	.323	.11	1.633	....
	5	.292	.231	42.11[illegible]	....
Adinfer	1	.367	.114	1.14	....
	2	.337	.10	.861	....
	3	.307	.094	.526	....
	4	.262	.093	.774	....
	5	.286	.103	2.402	....
	6	.30	.106	1.208	....
	7	.288	.084	.125	....
	8	.253	.071	.077	....
Henin-sur-Cojeul	1	.289	.186	14.40	....
	2	.228	.115	2.53	....
	3	.262	.123	2.30	....
	4	.313	.096	1.15	....
	5	.268	.163	10.42	....
	6	.313	.094	.93	....
Achicourt	1	.277	.571	7.173	....
	2	.263	.292	7.698	....
	3	.278	.16	1.901	....
	4	.329	.149	1.288	....
	5	.295	.159	2.263	....
	6	.257	.57	35.968	....
	7	.278	.57	32.968	....
	8	.355	.14	2.68	....
	9	.317	.329	4.67	....
Croisilles	1	.334	.109	2.061	....
	2	.286	.108	.592	....
	3	.308	.114	.902	....
	4	.305	.103	1.511	....
	5	.265	.114	12.525	....

Chemical composition of the soils of France—Continued.

PAS-DE-CALAIS—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Croisilles	6	0.325	0.125	1.003	....
	7	.26	.157	16.67	....
	8	.282	.093	.459	....
La Herliere	1	.275	.075	2.917	....
	2	.273	.066	3.00	....
	3	.276	.08	1.904	....
	4	.249	.099	4.857	....
	5	.276	.089	2.145	....
Moyenneville	1	.309	.102	.614	....
	2	.317	.091	.208	....
Moyenneville	3	.317	.107	.774	....
	4	.306	.099	.811	....
	5	.215	.103	.381	....
	6	.345	.133	.684	....
Ablainzevelle	1	.316	.102	.603	....
	2	.162	.114	.59	....
	3	.304	.092	.359	....
	4	.266	.072	.251	....
	5	.269	.071	1.53	....
	6	.292	.102	.429	....
	7	.224	.073	1.845	....
	8	.25	.071	.102	....
	9	.269	.085	2.052	....
	10	.255	.061	.28	....
Havrincourt	1	.272	.111	1.537	....
	2	.237	.097	.799	....
	3	.283	.137	3.646	....
	4	.319	.103	.605	....
	5	.237	.124	3.469	....
	6	.390	.128	1.652	....
	7	.275	.09	.62	....
	8	.337	.159	.87	....
	9	.35	.106	.848	....
	10	.341	.122	2.628	....
	11	.25	.103	1.578	....
	12	.206	.27	39.918	....
Hesdignaul	1	.248	.081	.573	....
	2	.276	.087	.57	....
	3	.257	.139	.877	....
	4	.337	.116	1.087	....
	5	.268	.067	.245	....
	6	.205	.074	1.171	....
	7	.264	.073	.051	....
	8	.266	.072	.243	....
	9	.182	.095	.255	....
	10	.322	.126	1.413	....
Metz-en-Couture	1	.272	.116	2.536	....
	2	.228	.111	.93	....
	3	.227	.133	1.734	....
	4	.239	.107	.568	....
	5	.323	.131	.758	....
	6	.233	.105	.711	....
	7	.289	.118	2.344	....
	8	.218	.15	.876	....
	9	.218	.098	1.996	....
	10	.243	.105	.537	....
	11	.22	.103	2.599	....
Fontaine-les-Boulans	1	.308	.096	1.884	....
	2	.38	.314	11.117	....
	3	.365	.083	65.90	....
	4	.297	.073	3.899	....
	5	.503	.39	14.713	....
	6	.545	.422	30.198	....
Clairmarais	1	.253	.054	2.171	....
	2	.414	.088	.675	....
	3	.284	.07	1.514	....
	4	.26	.069	.902	....
	5	.36	.081	1.022	....
	6	.378	.26	33.837	....
	7	.31	.078	2.12	....
	8	.31	.142	16.783	....
	9	.53	.10	3.085	....
Wizernes	1	.249	.074	.253	....
	2	.379	.063	1.059	....
	3	.271	.06	1.33	....
Racquinghem	1	.385	.072	.00	....
	2	.31	.093	.671	....
	3	.28	.099	.774	....
	4	.266	.086	1.224	....

Chemical composition of the soils of France—Continued.

PAS-DE-CALAIS—Continued.

Description and locality.	Original sample No.	Potash (K$_2$O).	Phosphoric acid (P$_2$O$_5$).	Lime (CaCO$_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Racquinghem	5	0.353	0 114	1.237	....
	6	.282	.039	1.003	....
	7	.557	.045	.929	....
	8	.761	.038	.608	....
	9	.178	.00	.00	....
Houlle	1	.232	.085	2.204	....
	2	.245	.161	28.211	....
	3	.279	.105	4.167	....
	4	.21	.111	2.648	....
	5	.178	.102	3.439	....
Moulle	1	.217	.082	2.203	....
	2	.171	.068	1.463	....
	3	.279	.105	4.167	....
	4	.21	.111	2.648	....
	5	.178	.102	3.439	....
Zoteux	1	.201	.126	2.08	....
	2	.293	.117	.436	....
	3	.287	.223	6.007	....
	4	.395	.209	1.807	....
	5	.196	.104	.212	....
	6	.272	.193	4.813	....
Mentque-Northecourt	1	.144	.162	61.819	....
	2	.292	.141	12.013	....
	3	.196	.141	6.114	....
	4	.297	.159	7.612	....
	5	.197	.151	39.253	....
	6	.266	.133	11.502	....
Isques	1	.404	.176	7.955	....
	2	.314	.139	1.005	....
	3	.199	.073	2.163	....
	4	.236	.092	.174	....
	5	.234	.09	.242	....
	6	.466	.257	9.746	....
Hubersent	1	.358	.248	8.238	....
	2	.147	.136	32.749	....
	3	.202	.093	3.213	....
	4	.272	.079	.328	....
	5	.211	.084	2.803	....
	6	.20	.071	.092	....
Bailleul-les-Pernes	1	.357	.066	23.731	....
	2	.243	.079	.796	....
	3	.301	.083	1.466	....
	4	.214	.065	1.247	....
	5	.287	.121	.873	....
	6	.30	.175	6.479	....
Auchy-lez-Hesdin	1	.195	.124	3.594	....
	2	.224	.091	.332	....
	3	.27	.119	.694	....
Rang-du-Fliers	1	.23	.057	18.422	....
	2	.135	.086	2.065	....
	3	.225	.277	17.465	....
	4	.219	.061	21.053	....
	5	.208	.051	17.912	....
	6	.143	.083	14.489	....
Labourse	1	.40	.219	25.177	....
	2	.325	.225	23.305	....
	3	.281	.131	23.511	....
	4	.234	.087	1.00	....
	5	.257	.102	1.678	....
	6	.306	.219	23.619	....
	7	.342	.208	19.108	....
Feuchy	1	.329	.183	6.948	....
	2	.254	.086	.78	....
	3	.316	.092	1.124	....
	4	.165	.103	.55	....
	5	.317	.285	27.373	....
	6	.403	.189	7.627	....
Coupelle-Vielle	1	.232	.10	4.968	....
Boiry-Notre-Dame	1	.306	.092	.715	....
	2	.275	.092	.756	....
	3	.292	.088	.745	....
	4	.268	.088	.817	....
	5	.242	.093	1.069	....
	6	.277	.081	1.377	....
	7	.185	.043	.258	....
	8	.276	.098	.50	....
	9	.281	.077	.76	....
	10	.30	.086	.753	....
	11	.321	.185	18.21	....

Chemical composition of the soils of France—Continued.

PAS-DE-CALAIS—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Boiry-Notre-Dame	12	0.297	0.073	0.64	....
	13	.28	.082	.372	....
	14	.251	.078	.616	....
Givenchy-en-Gohelle	1	.315	.136	1.224	....
	2	.366	.132	1.283	....
	3	.386	.155	3.864	....
	4	.282	.127	.88	....
	5	.367	.124	5.42	....
	6	.436	.178	5.891	....
Penin	1	.306	.119	.769	....
	2	.261	.149	9.243	....
	3	.333	.149	3.681	....
	4	.203	.202	63.776	....
	5	.267	.139	1.119	....
	6	.331	.14	2.472	....
Baralle	1	.245	.093	2.246	....
	2	.224	.102	1.763	....
	3	.262	.272	14.719	....
	4	.299	.133	.741	....
	5	.279	.249	9.838	....
	6	.331	.164	3.219	....
Rebergues	1	.35	.206	14.421	....
	2	.647	.126	1.495	....
	3	.27	.222	47.525	....
	4	.32	.373	11.439	....
	5	.384	.164	81.513	....
	6	.189	.312	17.655	....
Agny	1	.39	.682	19.799	....
	2	.251	.163	2.2[illegible]5	....
	3	.236	.135	2.095	....
	4	.38	.192	4.135	....
	5	.298	.246	5.20	....
	6	.30	.258	11.348	....
Auchy-l-Hesdin	1	.221	.202	1.268	....
	2	.176	.239	47.327	....
	3	.208	.21	7.066	....
	4	.239	.125	4.61	....
Herbelles	1	.244	.097	.708	....
	2	.27	.114	.273	....
	3	.238	.093	.765	....
	4	.241	.201	43.37	....
	5	.206	.095	.586	....
	6	.336	.155	7.123	....
Beussent	1	.411	.187	16.211	....
	2	.241	.134	51.008	....
	3	.293	.084	2.564	....
	4	.369	.135	3.493	....
	5	.273	.096	.716	....
	6	.224	.116	5.975	....
Divion	1	.224	.084	.978	....
	2	.237	.124	3.626	....
	3	.167	.046	.434	....
	4	.257	.116	4.754	....
	5	.19	.096	.869	....
	6	.239	.176	2.583	....
Aix-en-Issart	1	.328	.091	.331	....
	2	.323	.142	.888	....
	3	.292	.116	.316	....
	4	.152	.307	36.02	....
	5	.259	.09	1.004	....
	6	.247	.167	6.025	....
Hermies	1	.40	.269	6.881	....
	2	.341	.167	6.882	....
	3	.327	.159	2.329	....
	4	.27	.17	4.729	....
	5	.289	.124	.561	....
	6	.269	.138	1.413	....
Cherisy	1	.202	.121	1.026	....
	2	.228	.34	23.132	....
	3	.336	.133	.924	....
	4	.322	.20	.975	....
	5	.259	.174	3.929	....
	6	.173	.162	.839	....
Guarbecque	1	.296	.10	1.245	....
	2	.337	.097	1.114	....
	3	.294	.13	2.24	....
	4	.302	.128	1.312	....
	5	.219	.065	.788	....
	6	.308	.106	2.146	....

Chemical composition of the soils of France—Continued.

PAS-DE-CALAIS—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Isel-les-Hameau	1	0.202	0.107	0.646	....
	2	.219	.225	38.899	....
	3	.279	.121	1.975	....
	4	.26	.087	.618	....
	5	.209	.091	.808	....
	6	.303	.12	2.784	....
	7	.277	.111	1.671	....
Camiers	1	.125	.179	48.777	....
	2	.119	.071	2.05	....
	3	.329	.379	9.588	....
	4	.213	.089	1.746	....
	5	.181	.163	41.025	....
	6	.235	.144	68.206	....
	7	.156	.119	6.145	....
	8	.207	.089	.277	....
Le Transloy	1	.242	.081	.914	....
	2	.279	.122	.52	....
	3	.217	.093	.426	....
	4	.219	.118	.537	....
	5	.254	.132	1.247	....
	6	.296	.121	.769	....
Blendecques	1	.26	.075	.877	....
	3	.186	.08	.175	....
	5	.133	.089	.289	....
	7	.205	.101	2.063	....
	9	.22	.203	11.44	....
	11	.192	.167	13.74	....
Fleurbaix	1	.321	.09	.997	....
	2	.34	.083	.94	....
	3	.372	.113	.739	....
	4	.358	.105	2.086	....
Bernieulles	1	.277	.083	.322	....
	2	.275	.079	5.241	....
	3	.239	.091	.854	....
	4	.221	.081	2.599	....
	5	.214	.089	1.053	....
	6	.339	.077	4.612	....
Duisans	1	.235	.111	1.348	....
	2	.361	.198	2.94	....
	3	.298	.089	.834	....
	4	.326	.12	.528	....
	5	.281	.158	1.989	....
	6	.209	.221	48.356	....
	7	.292	.126	5.413	....
Bucquoy (Essart)	1	.233	.08	6.333	....
	2	.275	.136	1.469	....
	3	.268	.146	.606	....
	4	.272	.185	.546	....
	5	.27	.133	.528	....
Louez	3	.291	.213	4.702	....
Ablainzevelle	5	.245	.172	.575	....
	6	.287	.132	.661	....
Frevent	8	.265	.088	1.069	....
Les Attaques	10	.226	.148	13.177	....
Ablainzevelle	11	.236	.096	.527	....
Oisy-le-Verger	13	.337	.094	1.367	....
Lumbres	14	.292	.108	2.378	....
	15	.212	.157	5.747	....
Lagnicourt	16	.343	.119	1.328	....
Bethune	17	.303	.144	1.59	....
Bapaume	19	.283	.105	.625	....
Campagne-les-Hesdin	21	.222	.103	.985	....
Fouquieres	23	.231	.072	5.201	....
Bapaume	25	.223	.122	.775	....
Oignies	26	.206	.063	.586	....
Auchy-lez-La-Bassee	28	.238	.133	2.201	....
Oignies	1	.18	.053	.455	....
Ecoust-Saint-Mein	1	.258	.182	2.172	....
	2	.284	.124	.827	....
	3	.256	.128	.586	....
Béthune	1	.209	.09	1.379	....
	2	.224	.092	1.031	....

Chemical composition of the soils of France—Continued.

BOUCHES-DU-RHONE.[a]

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
La Crau	1	0.241	0.099	0.35	0.482
	2	.221	.088	.708	.382
	3	.204	.088	1.64	.498
	4	.177	.103	.464	.616
	5	.416	.128	1.588	.56
	6	.339	.091	.384	.37
	7	.491	.053	.972	.612
	8	.341	.197	12.00	.854
Limon de Durance	....	.26	.102	23.75	.833
		.252	.108	20.905	.989
		.353	.109	23.12	1.15
		.312	.104	20.777	.94
Limon du Rhone	....	.396	.118	23.05	.358
Sables du Rhone	1	.213	.112	.666	31.50
	2	.20	.101	.53	32.40
	3	.082	.094	.32	16.83
	4	.07	.078	.56	18.30
	5	.062	.069	.52	19.30
	6	.094	.104	.587	19.80
	7	.091	.094	.586	20.20
	8	.062	.069	.421	24.50
	9	.093	.078	.629	22.50
	10	.059	.101	.48	23.60
	11	.06	.077	.547	21.41
	12	.06	.093	.53	27.65
	13	.111	.135	.404	18.40
	14	.085	.15	.157	34.45
	15	.065	.129	.437	22.10
	16	.076	.124	.53	22.15
	17	.111	.15	.52	21.45
	18	.163	.148	.648	22.10
	19	.066	.078	.530	17.30
	20	.073	.096	.578	17.56
	21	.399	.13	1.657	30.30
	22	.198	.14	.684	24.40
	23	.129	.122	.731	19.00
	24	.21	.138	.462	21.70
	25	.078	.106	.547	20.40
	26	.085	.13	.478	18.76
	27	.085	.126	.58	22.28
	28	.074	.111	.534	20.00
	29	.316	.165	.892	25.25
	30	.181	.128	.606	20.30
	31	.153	.134	.597	20.25
	32	.222	.18	.714	22.44
	33	.236	.137	.86	26.40
	34	.075	.076	.612	18.24
La Camargue	1	.224	.159	1.136	31.87
	2	.212	.16	.944	33.59
	3	.419	.169	1.048	32.60
	4	.76	.155	1.387	34.50
	5	.545	.145	1.106	33.87
	6	.29	.145	1.162	33.97
	7	.418	.153	1.228	31.85
	8	.224	.139	1.518	32.40
	9	.183	.14	.875	24.20
	10	.217	.16	.94	25.21
	11	.249	.147	1.080	32.75
	12	.298	.15	1.039	32.22
	13	.412	.133	1.51	35.85
	14	.308	.14	1.107	29.80
	15	.268	.145	1.104	33.75
	16	.255	.14	....	32.50
	17	.21	.125	1.201	31.93
	18	.278	.135	1.065	32.14
	19	.429	.16	1.013	30.95
	20	.182	.153	.992	25.60
	21	.374	.099	1.046	34.86
	22	.472	.108	1.096	32.90
	23	.547	.125	.974	38.63
	24	.437	.143	1.104	33.70
	25	.49	.138	1.042	34.70
	26	.525	.144	1.065	36.40

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[a] Gastine. Ann. Sci., Agron., 1898, 155, 240. Bull. Min. Agr., France, 1897, pp. 614-655.

Chemical composition of the soils of France—Continued.

MARNE.[a]

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Verzy: Verzenay	1	0.171	0.205	14.50	0.007
	2	.186	.134	19.00	.036
	3	.237	.215	17.50	.011
	4	.115	.169	14.10	.009
	5	.186	.122	10.15	.126
Verzy	1	.205	.18	8.20	.003
	2	.136	.186	18.30	.007
	3	.19	.216	10.20	.043
	4	.169	.133	8.00	.034
	5	.135	.095	1.74	.091
Villers-Marmery	1	.241	.186	9.30	.092
	2	.219	.17	12.50	.101
	3	.278	.195	14.00	.106
	4	.252	.142	2.30	.086
	5	.258	.242	25.20	.139
	6	.18	.264	26.80	.097
	7	.168	.200	19.60	.048
Ville-en-Tardenois: Pargny	1	.186	.153	32.10	.164
	2	.168	.123	27.80	.137
	3	.246	.111	14.50	.288
	4	...	.058	36.00	...
	5	.23	.089	16.50	.205
	6	.144	.061	4.00	.108
Villedomange	1	.263	.165	9.30	.262
	2	.281	.13	13.30	.249
Courmas	1	.534	.094	30.50	.146
	2	.622	.08	22.50	1.124
Bouzy	1	.139	.161	11.35	.295
	2	.257	.14	8.85	.016

CHARANTE-INFERIEURE.[b]

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
Perigny	...	0.434	0.069	...	...
	...	.482	.142	...	...
Chevillon	...	.778	.146	...	...
	...	.379	.124	...	...
	...	.742	.147	...	...

LOIRE-INFERIEURE.[c]

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
Nozay	1	0.07	0.08	0.07	0.07
	2	.05	.04	.05	.10
	3	.04	.04	.05	.04
	4	.10	.05	.13	.20
	5	.02	.07	.02	.02
	6	.05	.06	.09	.05
	7	.07	.03	.02	.08
	8	.13	.16	.09	.17
	9	.02	.17	.04	.02
	10	.07	.02	.09	.11
	11	.03	.09	.03	.05
	12	.11	.07	.11	.12
	13	.03	.05	.03	.03
	14	.05	.05	.03	.03
	15	.06	.15	.07	.03
	16	.10	.14	.12	.08
	17	.08	.12	.09	.14
	18	.08	.13	.07	.10
	19	.09	.15	.10	.16
	20	.12	.14	.12	[illegible]
	21	.04	.08	.04	[illegible]
	22	.11	.14	.09	.16
	23	.05	.10	.11	.06
	24	.04	.13	.11	.06
	25	.05	.13	.08	.06
	26	.06	.15	.04	.06
	27	.04	.11	.05	.01
	28	.11	.12	.07	.06
	29	.11	.13	.04	.09

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[a] Muntz. Bull. Min. Agr., France, 1893, 170-210.

[b] Verneuil. Prog. Agr. Viticole, 21, 401 (1894).

[c] Bourgeois. Rapports, 1891.

Chemical composition of the soils of France—Continued.

LOIRE-INFERIEURE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Nozay	30	0.06	0.09	0.06	0.05
	31	.04	.05	.04	.02
	32	.07	.08	.06	.05
	33	.06	.08	.09	.06
	34	.13	.11	.13	.05
	35	.08	.01	.07	.02
	36	.07	.03	.02	.01
	37	.05	.03	.02	.01
	38	.03	.04	.04	.03
	39	.05	.04	.06	.08
	40	.06	.10	.17	.11
	41	.04	.03	.05	.05
	42	.06	.03	.05	.06
	43	.04	.08	.03	.02
	44	.07	.05	.11	.04
	45	.05	.05	.07	.06
	46	.10	.06	.07	.06
	47	.18	.07	.04	.03
	48	.09	.13	.08	.08
	49	.06	.12	.05	.05
	50	.13	.14	.08	.04
	51	.12	.12	.11	.10
	52	.10	.13	.11	.06
	53	.11	.10	.13	.05
	54	.15	.11	.12	.07
	55	.13	.10	.11	.05
	56	.11	.11	.11	.13
	57	.09	.09	.11	.06
	58	.12	.09	.07	.08
	59	.09	.10	.10	.09
	60	.11	.10	.10	.10
	61	.16	.13	.18	.07
	62	.09	.10	.10	.11
	63	.10	.12	.15	.14
	64	.09	.11	.08	.10
	65	.09	.05	.11	.23
	66	.03	.04	.04	.19
	67	.03	.05	.06	.21
	68	.04	.05	.06	.19
	69	.08	.11	.12	.39
	70	.13	.11	.15	.43
	71	.08	.08	.09	.25
	72	.07	.07	.06	.19
	73	.08	.06	.14	.25
	74	.14	.06	.07	.19
	75	.07	.06	.07	.15
	76	.09	.03	.11	.07
	77	.03	.02	.04	.04
	78	.05	.02	.06	.07
	79	.02	.02	.04	.04
	80	.04	.01	.05	.08
	81	.02	.01	.02	.05
	82	.06	.01	.06	.09
	83	.09	.05	.07	.05
	84	.03	.02	.03	.02
	85	.07	.08	.12	.04
	86	.11	.10	.13	.07
	87	.09	.06	.09	.04
	88	.12	.10	.15	.10
	89	.05	.05	.08	.04
	90	.05	.07	.08	.08
	91	.07	.02	.04	.05
	92	.04	.03	.04	.01
	93	.09	.08	.14	.11
	94	.06	.05	.08	.16
	95	.09	.05	.10	.05
	96	.13	.06	.14	.08
	97	.12	.08	.19	.11
	98	.11	Traces.	.02	.05
	99	.10	.05	.14	.07
	100	.14	.08	.09	.06
	101	.13	.06	.19	.10
	102	.12	.02	.14	.10
	103	.15	.08	.22	.16
	104	.12	.05	.19	.12
	105	.08	.09	.20	.14
	106	.06	.09	.10	.05

Chemical composition of the soils of France—Continued.

LOIRE-INFERIEURE—Continued.

Description and locality.	Original sample No.	Potash (K$_2$O).	Phosphoric acid (P$_2$O$_5$).	Lime (CaCO$_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Nozay	107	0.19	0.10	0.15	0.12
	108	.07	.07	.11	.06
	109	.08	.11	.15	.10
	110	.13	.12	.16	.18
	111	.09	.12	.13	.12
	112	.04	.12	.31	.02
	113	.08	.10	.24	.07
	114	.09	.11	.15	.10
	115	.08	.09	.20	.11
	116	.10	.11	.20	.10
	117	.13	.13	.17	.12
	118	.06	.07	.19	.12
	119	.10	.13	.10	.12
	120	.15	.14	.14	.23
	121	.07	.09	.08	.04
	122	.03	.04	.04	.06
	123	.08	.12	.31	.11
	124	.05	.11	.23	.06
	125	.05	.15	.23	.08
	126	.07	.12	.13	.08
	127	.11	.10	.13	.15
	128	.12	.10	.10	.13
	129	.13	.14	.09	.08
	130	.08	.06	.13	.05
	131	.10	.14	.09	.06
	132	.20	.07	.15	.22
	133	.13	.05	.09	.12
	134	.06	.04	.05	.05
	135	.08	.07	.15	.06
	136	.06	.07	.07	.04
	137	.07	.08	.12	.07
	138	.09	.07	.12	.08
	139	.03	.03	.05	.02
	140	.02	.03	.04	.02
	141	.14	.09	.32	.12
	142	.07	.07	.09	.06
	143	.07	.11	.11	.06
	144	.05	.18	.62	.13
	145	.06	.09	.15	.06
	146	.09	.04	.05	.05
	147	.12	.08	.18	.07
	148	.09	.04	.10	.21
	149	.08	.08	.13	.21
	150	.10	.04	.11	.13
	151	.10	.07	.09	.14
	152	.10	.07	.09	.11
	153	.08	.06	.06	.16
	154	.13	.03	.10	.16
	155	.10	.07	.18	.26
	156	.11	.05	.12	.15
	157	.06	.02	.04	.07
	158	.07	05	.05	.10
	159	.07	03	.08	.06
	160	.03	02	.06	.07
	161	.12	05	.08	.14
	162	.07	.09	.05	.09
	163	.09	05	.05	.11
	164	.06	.02	.06	.05
	165	.08	.03	.08	.31
	166	.13	.04	.09	.28
	167	.04	.03	.05	.06
	168	.05	.07	.08	.07
	169	.04	.04	.08	.04
	170	.21	.06	.14	.37
	171	.10	.07	.11	.20
	172	.13	09	.20	.33
St. Viand: Plessis-Grimand (appx. 250 hectares)	1	.07	.03	.16	.13
	2	.21	.04	.17	.15
	3	.17	.04	.29	.27
	4	.14	.04	.26	.16
	5	.12	.06	.16	.12
	6	.23	.08	.13	.21
	7	.21	.06	.10	.26
	8	.09	.06	.15	.06
	9	.17	.04	.16	.19
	10	.20	.09	.13	.14
	11	.24	.03	.35	.60

Chemical composition of the soils of France—Continued.

LOIRE-INFERIEURE—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
St. Viand: Plessis-Grimand (appx. 250 hectares)	12	0.12	0.06	0.32	0.23
	13	.14	.06	.18	.12
	14	.22	.08	.18	.31
	15	.19	.07	.12	.30
	16	.16	.07	.16	.24
	17	.21	.06	.18	.56
	18	.17	.05	.47	.37
	19	.10	.09	.16	.44
	20	.14	.05	.30	.28
	21	.14	.04	.24	.20
	22	.15	.06	.08	.14
	23	.21	.05	.30	.17
	24	.15	.06	.15	.31
	25	.10	.05	.18	.24
	26	.16	.06	.27	.33
	27	.12	.04	.14	.18
	28	.18	.06	.11	.26
	29	.15	.08	.22	.15
	30	.10	.07	.39	.23
	31	.17	.08	.18	.25
	32	.15	.09	.33	.34
	33	.12	.04	.12	.38
	34	.11	.06	.12	.40
	35	.20	.06	.10	.12
	36	.09	.04	.07	.08
	37	.10	.10	.06	.04
	38	.18	.06	.08	.07
	39	.20	.06	.20	.09
	40	.18	.08	.12	.51
	41	.12	.04	.11	.12
	42	.15	.07	.21	.76
	43	.10	.06	.15	.54
	44	.11	.05	.12	.45
	45	.15	.06	.27	.30
	46	.20	.06	.12	.20
	47	.14	.08	.22	.17
	48	.12	.04	.06	.27
	49	.25	.08	.09	.20
	50	.12	.04	.05	.04
	51	.18	.07	.21	.36
	52	.20	.08	.10	.25
	53	.22	.06	.16	.34
	54	.12	.07	.09	.21
	55	.20	.06	.10	.12
	56	.22	.09	.18	.37
	57	.25	.06	.15	.31
	58	.25	.03	.17	.51
	59	.24	.07	.12	.11
	60	.22	.05	.09	.05
	61	.23	.07	.07	.08
	62	.21	.05	.09	.20
	63	.22	.07	.27	.10
	64	.15	.06	.10	.12
	65	.12	.05	.20	.15
	66	.13	.06	.19	.17
	67	.10	.04	.47	.13
	68	.14	.05	.13	.10
	69	.18	.06	.11	.30
	70	.17	.05	.38	.53
	71	.51	.04	.17	.12
	72	.16	.04	.18	.10
	73	.15	.04	.16	.09

L'HERAULT.[a]

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
Capestang: Alluvions de Capestang	1	0.131	0.095	15.164	....
	2	.114	.087	8.512	....
Murveil: Alluvions de l'orb	3	.117	.132	2.918	....
Thegan	4	.158	.107	3.87	....
Lignan	5	.10	.07	.006	....
Sauvian	6	.172	.09	.437	....
Lignan	7	.149	.138	3.466	....

[a] Lagatu and Semichon. Matériaux pour une Étude des Terres de Département de l'Hérault, 1893; Prog. Agr. et. Vitu. 19, 105, 162, 179, 233, 276, 447, 489 (1893).

Chemical composition of the soils of France—Continued.

L'HERAULT—Continued.

Description and locality	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Beziers	8	0.139	0.146	5.6[illegible]	
	9	.131	.179	3.846	
Villeneuve	10	.175	.134	2.635	
	11	.182	.15	4.584	
Lieuran: Alluvions de Libron		.134	.101	6.889	
Beziers		.109	.071	1.38	
Servian: Alluvions de la Tongue		.15	.137	6.368	
		.171	.108	8.288	
		.171	.154	6.944	
Saint-Thibery: Alluvions de l'Herault		.164	.155	7.224	
Bessan		.195	.14	7.28	
		.168	.20	7.112	
Agde		.174	.167	8.344	
		.20	.133	8.848	
Agde: Sables des dunes		.047	.088	11.088	
Lieuran: Diluvium de l'Epinouse		.167	.04	1.686	
Servian		.143	.042	.003	
Saint-Thibery		.192	.055	.431	
		.076	.06	.781	
		.147	.056	.896	
Beziers		.135	.047	.706	
Servian: Depots fluvio-volcanique		.122	.26	3.147	
Agde: Terrain pliocene		.258	.114	1.419	
		.121	.082	17.64	
Servian		.164	.081	3.214	
Autignec: Terrain miocene		.102	.15	12.712	
Murveil		.127	.095	6.72	
Pomerols		.20	.119	10.92	
Murveil		.103	.121	15.904	
Beziers		.044	.052	15.848	
Maureilham		.098	.157	15.344	
Capestang		.134	.162	11.76	
Pinet		.188	.054	17.304	
Beziers		.105	.177	24.136	
		.266	.136	28.836	
Pinet		.212	.038	30.408	
Beziers		.131	.092	14.84	
		.236	.139	23.016	

DORDOGNE.[a]

Description and locality	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
Terrains granitiques		0.255	0.034	0.012	
		.244	.0492	.0556	
		.235	.046	.0491	
				$CaCO_3$	
Terrains cretaces		.08	.0796	16.00	
		.069	.095	64.00	
Sables du Perigord		.0812	.0256	Traces.	
Saint-Nexans		.1445	.0256	Traces.	
Lunas: Bouvees Argilo-siliceuses		.059	.023		
Bouvees silico argileuses				$CaCO_3$	
Leves		.209	.069	22.40	
Saint-Alveres		.075	.079	16.00	
Laudais: Terrains tertiaires		.097	.02	.119	
		.195	.051	2.77	
		.258	.056	2.24	
		.319	.059	1.39	
Terrains quaternaires		.15	.0703	.2225	0.125
		.189	.0615	.184	

MEURTHE-ET-MOSELLE.[b]

Description and locality	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
Cirey: Grès Bigarres		0.1717	0.0523	0.0364	0.075
Bertrichamp: Gres Bigarres		.0901	.0212	.028	.10
Marnes		.1819	.0559	.0532	.05
Argile		.1972	.0634	.1512	.08

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[a] Ann. Inst. Nat. Agron., France, 14, 61 (1891-92).

[b] Bull. Sta. de la Loire-Inférieure, 1903-[illegible]

Chemical composition of the soils of France—Continued.

HAUTE-PYRENEES.[a]

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Vallée de Luz	....	0.455	0.123	0.0107	....
Prairie irrigeree	....	.098	.202	.0171	....
Prairie tourbeuse	....	.097	.394	.082	....
Prairie seche	....	.287	.128	.0137	....

EURE-ET-LOIRE.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
	1	0.096	0.069	0.84	0.148
	2	.081	.039	.39	.10
	3	.096	.051	.49	.092
	4	.105	.045	.91	.086
	5	.084	.056	1.09	.079
	6	.086	.036	.84	.086
	7	.076	.034	.53	.073
	8	.098	.061	.60	.084
	9	.072	.060	.47	.075
	10	.079	.047	.42	.078
	11	.086	.051	.58	.086

ÉPERNAY.[b]

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime ($CaCO_3$).	Magnesia (MgO).
Aoise: Mesnil-sur-Oger	1	0.178	0.186	28.95	0.025
	2	.169	.157	41.65	.088

[a] Faure. Ann. Inst. Nat. Agron. 13, 117 (1888–91).
[b] Station Agrm. de Chartres, Rapports, 1891–1892.

Chemical composition of the soils of Germany.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5)	Lime (CaO).	Magnesia (MgO).
HESSE.[a]		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Bundsandstein	....	0.25	0.17	0.35	0.31
		.32	.13	.39	.38
		.31	.12	.37	.30
Basalt	....	.11	.15	.89	1.16
Graudwacke	....	.23	.18	.30	1.15
Muschelkalk	....	.14	.09	.52	1.75
"Taunusgesteine"	243	.15	.07	.10	.06
Devonien	411	.21	.02	.13	.08
"Rotliegendes"	67	.57	.12	3.16	1.13
Tertiary	6	.37	.10	14.97	1.76
	15	.37	.11	12.41	1.42
	1	.45	.05	20.20	.83
	5	.29	....	28.80	2.16
	3	.31	.12	5.55	.78
	19	.31	.12	13.60	.78
Diluvium	25	.38	.06	.38	.06
	58	....	.06	3.24	.08
	7	.19	.09	15.95	1.50
	8	.26	.26	6.85	1.06
	16	.22	.15	6.46	.46
	16	.11	.25	17.68	2.07
Alluvium	10	.35	....	2.12	.63
	21	.23	.14	3.41	.42
	20	.29	.25	4.73	.53
	12	.21	....	9.00	.37
PRUSSIA.[b]					
Köslin: [c]					
Koppenow	....	.094	.0709	.109	....
Zdrewen	....	.133	.0853	.2505	....
Dubberzin	....	.0936	.0603	.2243	....

[a] Habernoll, Mitt. Landw. Inst. königl. Univ. Breslau, 2, 147 (1899). Haselhoff, Fühlings landw. Ztg., 55 73 (1906).
[b] Baessler, Ber. Thät. Agrik.-Chem. Vers. Samenc, Köslin, 1898, 1900.
[c] The potash analyses were made with 10 per cent hydrochloric acid. The phosphoric acid and lim results are based upon complete analyses.

Chemical composition of the soils of Germany—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
PRUSSIA—continued.					
Köslin—Continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Gross-Silber	....	0.0572	0.0653	0.1991	....
		.0577	.0488	.1336	....
Reinwasser	....	.0541	.0841	.1292	....
Kl.-Spiegel	....	.069	.118	.05	....
		.076	.075	.067	....
Garden	....	.068	.037	.134	....
Menhans	....	.06	.044	.109	....
Helenenau	....	.065	.065	.095	....
Gr.-Raddow	....	.044	.06	.082	....
Landechow	....	.083	.089	.156	....
Schinz	....	.038	.053	.035	....
Breitenberg	....	.058	.099	.185	....
Schmolsin	....	.03	.079	.072	....
Gr.-Mellen	....	.026	.092	.048	....
Knick	....	.03	.072	.15	....
WEST PRUSSIA.[a]					
Kainozoic	....	.081	.105	.182	0.422
		.065	.096	.147	.199
		.068	.094	.153	.175
		.052	.094	.14	.154
		.049	.098	.14	.137
		.027	.09	.233	.163
		.039	.053	.171	.059
		.078	.133	.783	.261
		.037	.069	.087	.044
		.078	.106	.898	.333
		.061	.065	.70	.103
		.061	.042	.847	.43
		.092	.054	.20	.028
Mesozoic	....	.039	.018	.683	.042
		066	.053	.343	.103
		.103	.03	2.507	.533
		.113	.025	22.067	.113
		.031	.06	3.24	.202
		.039	.021	.183	.144
		.056	.045	.347	.084
		.039	.047	.127	.096
		.05	.083	.027	.017
		.077	.115	.28	.065
		.047	.169	.386	.048
Paleozoic	....	.135	.058	4.403	.216
		.144	.171	2.60	.37
		.026	.034	.087	.019
		.188	.235	.297	.659
		.123	.192	1.63	.144
		.04	.028	Trace.	.019
		.129	.092	.293	.072
Eruptive rocks	....	.179	.041	.753	.176
		.212	.219	1.849	.574
WEST PRUSSIA.[b]					
Humus soils	3	.14	.22	1.03	....
	8	.34	.44	2.85	....
	13	.10	.13	1.40	....
	21	.05	.29	2.37	....
Heavy soils	5	.15	.35	1.91	....
	7	.48	.13	.88	....
	9	.21	.32	.77	....
	11	.17	.11	.19	....
	17	.30	.09	.86	....
	20	.17	.12	.84	....
	22	.75	.13	1.77	....
	23	.23	.11	.41	....
	27	.58	.13	.67	....
	28	.25	.10	.31	....
	29	.18	.09	.44	....
Medium soils	1	.17	.09	.38	....
	2	.11	.08	.19	....
	12	.13	.05	.40	....
	14	.17	.08	.35	....
	18	.16	.12	.27	....
	24	.16	.09	.17	....
	25	.09	.09	.16	....
	26	.19	.16	6.40	....

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[a] Wohltmann, Das Nahrestoff-Kapital west-deutscher Böden, Bonn, 1901. Analyses with cold hydrochloric acid.

[b] Schmoeger Landw. Jahrb., vol. 34, p. 160 (1905). Blanck, Landw. Vers.-Sta., 60, 405 (1904). The first 2 soils were treated with hot concentrated hydrochloric acid. The following 5 soils were treated with double strength hydrochloric acid, and for the last 2 soils complete analyses are given.

Chemical composition of the soils of Germany—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
WEST PRUSSIA—continued.					
		Per cent.	*Per cent*	*Per cent.*	*Per cent.*
Light soils	4	0.21	0.10	0.18	....
	6	.11	.23	.43	....
	10	.04	.19	.11	....
	15	.07	.08	.13	....
	16	.07	.09	.18	....
	19	.07	.09	.26	....
	30	.08	.10	.17	....
Westphalia[a] Lünten Dörmern	1	.047	.016	.076	....
	9	.063	.036	.128	....
	20	.265	.028	.077	....
	26	.066	.02	.40	....
	4	.049	.022	.157	....
	3	.419	.061	.571	....
	2	.074	.016	.157	....
	18	.024	.016	.225	....
	11	.148	.023	.152	....
	5	.304	.015	.081	....
	13	.129	.019	.251	....
	22	.031	.019	.178	....
	24	.025	.026	.192	....
	25	.03	.011	.103	....
	26	.066	.029	.40	....
	7	.149	.04	.027	....
	8	.05	.012	.017	....
	5	.304	.015	.081	....
	16	.256	.01	.025	....
Wettringen, Bilk, and Haddrup:					
I (a)	0	.029	.03	.097	0.063
	3	.033	.018	.192	.045
	5	.051	.003	.133	Trace.
	8	.019	.011	.007	Trace.
	9	.04	.01	.007	Trace.
	15	.019	Trace.	.079	.048
I	0	.092	.02	.036	.032
	1	.063	.009	.30	.032
	4	.04	.021	.01	.029
	9	.024	.021	.029	.031
	11	.009	.003	.05	.036
	14	....	....	....	....
	16	.014	.092	.125	Trace.
	19	.033	.029	.148	.043
	31	.06	.058	.255	.034
II	1	.019	Trace.	.075	.039
	2	.01	.070	.126	.071
	5	.033	.022	.097	.016
	6	.032	.01	.203	.00
	12	.069	.00	.00	.00
	16	.023	.016	.056	.00
	19	....	....	....	....
	21	.023	.016	.089	.00
	22	....	....	....	....
	23	....	....	....	....
	24	....	....	....	....
	25	.051	Trace.	.032	.01
III	1	.049	.014	.143	.003
	2	.025	.008	.00	.018
	5	.057	Trace.	.072	.035
	10	.04	.005	Trace.	.033
	11	....	....	....	....
	13	.018	.006	.18	Trace.
IV	1	.019	.00	.01	.00
	5	.024	.014	.003	.024
	10	.05	.007	.138	.004
V	1	.013	.006	.176	.025
	3	.014	.017	.182	.014
	5	.066	.066	.058	.20
	8	.014	.00	.139	.031
	9	....	....	....	....
VI	1	.028	.03	.014	.008
	2	.024	.018	.028	.014
	4	....	....	....	....
	5	....	....	....	....
	6	.016	.023	.286	.083

[a] Haselhoff and Breme. Die Haideböden. Westfalens, 1899 to 1903.

Chemical composition of the soils of Germany—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
WEST PRUSSIA—continued.					
Wettringen, Bilk, and Haddrup—Cont'd.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent*
VII	2	0.016	0.015	0.021	0.021
	7	.019	.015	.261	.003
	8				
	16	.003	.012	.025	.007
	22	.027	.014	.05	Trace.
	23				
VIII	1	.022	.11	.05	Trace.
	5				
	8	.014	.056	.075	.023
	12	.038	.031	.072	.028
	13				
	16	.027	.007	.01	.016
	29	.028	.018	.063	.002
IX	2	.091	.066	.063	.102
	3				
	12	.05	.026	.043	.009
	14	.023	.00	.041	.081
	20	.029	.00	.051	.092
	21	.032	.00	.075	.037
	24				
	28	.036	.028	.083	.018
	32	.049	.013	.065	.017
X	3				
	4	.027	.016	Trace.	.031
	9	.061	.014	Trace.	.014
	13	.044	.023	.155	.004
	16	.053	.013	.075	Trace.
Handorf and Telgte	3	.008	.071	.112	.018
	6	.075	.012	.023	.008
	1	.057	.019	.077	.022
	2	.088	.032	.135	.017
	3	.026	.025	.119	.005
	5	.012	.038	.00	.008
	10	.106	.028	.114	.032
	15	.127	.051	.046	.129
	20	.114	.053	.165	.131
	1	.103	.041	.023	.17
	8	.037	.043	.112	.123
	10	.05	.032	.096	.037
	18	.068	.097	.092	.08
	20	.025	.16	.16	.14
St. Mauritz, Gelmer, and Gimbte	3	.023	.039	.365	.062
	4	.129	.027	.178	
	5	.071	.028	.042	Trace.
	7	.01	.039	.543	.045
	8	.201	.028	.337	.094
	9	.086	.036	.117	.00
	12	.157	.058	.154	.02
	3	.023	.039	.365	.062
	4	.129	.027	.178	
	8	.201	.028	.337	.094
	12	.053	.024	.348	.00
	15	.093	.04	.138	.01
Wiedenbrück		.054	.021	.12	.113
		.083	.053	.348	.053
		.083	.062	.288	.079
		.073	.07	.961	.278
		.06	.032	.108	.049
		.073	.006	.075	.021
		.115	.024	.14	.054
		.045	.011	.063	.023
		.009	.022	.048	.017
		.148	.011	.418	.082
		.023	.078	.183	.076
		.146	.10	.105	.081
		.048	.027	.194	.045
		.006	.009	.052	.01
		.022	.069	.088	.031
		.004	.016	.073	.027
		.004	.023	.116	.032
		.014	.032	.174	.191
		.025	.037	.091	.028
		.006	.031	.079	.02
		.051	.066	.205	.013
		.021	.034	.113	.914

Chemical composition of the soils of Germany—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
WEST PRUSSIA—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Weidenbrück		0.017	0.029	0.08	0.015
		.02	.029	.04	.03
		.101	.03	.165	.02
		.092	.013	.03	.09
		.018	.018	.21	.03
		.040	.029	.04	.03
		.064	.014	.061	.011
		.043	.027	.12	.01
		.017	.085	.048	.03
		.068	.024	.093	.04
		.157	.015	.078	.02
		.07	.034	.085	.04
		.021	.03	.012	.03
		.039	.014	.028	.011
		.014	.064	.038	.09
		.042	.009	.063	.02
		.123	.014	.08	.05
		.019	.016	.14	.02
		.033	.032	.23	.02
		.061	.022	.51	.09
		.041	.015	.035	.03
		.076	.008	.048	.06
		.085	.01	.028	....
		.04	.011	.023	....
		.024	.021	.073	.06
		.033	.041	.09	.08
		.052	.038	.07	.06
		.042	.023	.10	.07
		.056	.026	.178	.04
		.059	.008	.035	.04
		.058	.019	.08	.06
		.025	.022	.023	.01
		.051	.021	.04	.09
		.035	.009	.02	....
		.06	.032	.025	.02
		.016	.035	.15	.02
		.013	.029	.143	.01
		.099	.013	.043	.014
		.032	.018	.065	.01
		.047	.035	.043	Trace.
		.063	.019	.045	Trace.
		.062	.029	.04	.014
		.051	.008	.045	.09
		.126	.032	.035	.01
		.165	.012	.038	.05
		.041	.013	.062	.03
		.031	.009	.074	.09
		.015	.027	.123	.07
		.03	.066	.055	.05
		.063	Trace.	.012	Trace.
		.042	.005	.023	Trace.
		.036	.006	.09	.07
		.034	.011	.11	Trace.
		.048	Trace.	.038	Trace.
		.008	.021	.12	Trace.
		.079	.006	.005	Trace.
		.091	.021	.013	.07
		.065	.008	.01	Trace.
Arendsee [a]		.055	.048	.343	.04
Wessing [a]		.116	.158	.317	.12
Harpe [a]		.074	.072	.912	.06
Schurigshoff [a]		.094	.05	.285	.04
Schwemsal [a]		.191	.086	.563	.30
Lauchstadt [a]		.446	.084	.984	.2
Vitzenburg [a]		.339	.148	5.75	1.08
Wessnig [a]		.167	.08	.503	.32
		.510	.814	4.019	1.27
		.277	.158	.81	.56
EAST PRUSSIA		.3336	.1180	1.059	.205
		.3486	.1113	1.093	.159
		.68	.09	.41	1.16
		.81	.18	.48	1.57
		.14	.13	.50	1.17
		.15	.11	.38	.79
		.34	.11	1.08	.18
		3.10	.252	1.99	1.09
		3.23	.245	1.82	1.18

[a] Schneidewind, Meyer and Frese, Landw. Jahrb., 35, 927 (1906). Analyses made with 10 per cent hydrochloric acid, except in the case of phosphoric acid, where complete analyses are given.

Chemical composition of the soils of Germany—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
OLDENBURG.[a]					
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Marsh soils	1	2.23	0.25	4.34	1.66
	2	2.14	.21	4.24	1.41
	3	.73	.21	5.86	1.71
	4	.89	.18	6.57	1.81
	5	.62	.23	7.09	1.85
	6	.26	.12	.43	....
	7	.17	.08	2.52	....
	8	.45	.05	.10	....
	9	.41	.13	.14	....
	10	.43	.26	.50	....
	11	.44	.15	3.28	....
	12	.39	.11	3.28	....
	13	.62	.05	.11	....
	14	.44	.18	.19	....
	15	.44	.11	.24	....
	16	.38	.16	.28	....
	17	.46	.10	....	....
	18	.33	.13	....	....
	19	.24	.10	.21	....
	20	.62	.12	.95	....
	21	.37	.11	.42	....
	22	.38	.13	.39	....
	23	.33	.09	.33	....
	24	.33	.16	1.53	....
	25	.82	.16	1.26	....
	26	.46	.11	1.16	....
	27	.57	.14	.78	....
	28	.54	.18	.39	....
	29	.32	.10	.69	....
	30	.43	.12	2.40	....
	31	.49	.12	.46	....
	32	.55	.20	.46	....
	33	.56	.19	.47	....
	34	.60	.19	.49	....
	35	1.00	.28	4.99	....
	36	.18	.08	4.48	....
	37	.39	.11	.52	....
	38	.35	.10	.46	....
Blauhandter Groden	....	.59	.151	2.27	....
Ellenserdammer Groden	....	.66	.152	3.87	....
Friedrich August Groden	....	.65	.193	4.88	....
Adelheids Groden	....	.62	.235	5.16	....
Peters Groden	....	.56	.25	5.28	....
BAVARIA AND WURTTEMBERG.[b]					
Moor soils	608	.091	.276	4.82	....
	597	.077	.272	3.51	....
	610	.099	.256	2.77	....
	609	.088	.34	2.13	....
	612	.046	.183	1.50	....
	611	.056	.266	1.20	....
	613	.060	.243	.921	....
	232	....	.185	2.85	....
	233	.237	.211	1.19	....
	234	.1265	.397	1.25	....
	235	.067	.165	.471	....
	69	.0754	....	....	....
	248	.0761	.139	.529	....
	223	.0611	.119	.387	....
	219	.0669	.146	.681	....
	243	.0738	.147	.506	....
	246	.0665	.122	.338	....
	224	.0565	.156	.454	....
	451	.0517	.127	.450	....
	242	.0638	.133	.557	....
	241	.0588	.121	.331	....
	249	.0478	.085	.61	....
	452	.0645	.142	.341	....
	453	.0682	.127	.254	....
	222	.0496	.117	.397	....
	454	....	.107	.325	....
	247	.0467	.129	.421	....
	244	.0508	.094	.377	....
	220	....	.069	.168	....

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[a] Schucht, Jour. Landw., 53, p. 322 (1905). Maercker, Zusammensetzung und Düngerbedürfnis Oldenburg Marscherden und deren Bewirtschatung, Berlin, 1896.

[b] Vierteljahresschr. bayer. Landw.-Rat, 10, Ber. Arbeiten Moorkult. 1904.

Chemical composition of the soils of Germany—Continued.

Description and locality.	Original sample No.	Potash (K_2O).	Phosphoric acid (P_2O_5).	Lime (CaO).	Magnesia (MgO).
BAVARIA AND WURTTEMBERG—continued.		*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Moor soils	221	....	0.094	0.535	....
	237	0.0365	.076	.368	....
	245	.0386	.106	.214	....
	239	.032	.093	.371	....
	240	.0307	.065	.516	....
	236	.028	.066	.344	....
	238	.0238	.061	.333	....
	580	.116	.097	.36	....
	581	.097	.098	.404	....
	593	.075	.125	.28	....
	594	.074	.151	.257	....
	592	.065	.106	.439	....
	585	.076	.152	.272	....
	589	.0586	.121	.217	....
	591	.0457	.135	.306	....
	595	.064	.114	.228	....
	577	.063	.18	.24	....
	586	.074	.153	.356	....
	578	....	.164	.29	....
	583	.056	.108	.289	....
	575	.050	.194	.32	....
	572	.061	.146	.312	....
	579	.047	.162	.336	....
	587	.0451	.117	.259	....
	576	.041	.129	.298	....
	574	.046	.127	.367	....
	588	.043	.113	.265	....
	584	.042	.088	.318	....
	590	.037	.092	.517	....
	582	.033	.096	.313	....
	573	.021	.121	.401	....
	544	.0794	.184	.383	....
	542	.0587	.152	.39	....
	1076	.0668	.259	.535	....
	547	.073	.206	.826	....
	540	.0629	.156	.89	....
	541	.0535	.119	.425	....
	536	....	.164	.419	....
	1074	.058	.217	.423	....
	1071	.063	.182	.58	....
	539	.0482	.158	1.02	....
	537	....	.106	.40	....
	538	.0473	.083	.615	....
	543	.039	.139	.825	....
	546	.0293	.074	2.73	....
	1073	.042	.20	.576	....
	1075	.054	.207	.078	....
	1072	.041	.177	.906	....
	545	....	.094	.742	....
Loess soils[a]	1	.15	.16	14.95	0.96
	2	.12	.13	14.10	1.20
	3	.13	.13	12.50	1.20
	4	.14	.18	16.76	Trace.
	5	.12	.19	10.26	.61
	6	.18	.14	12.20	Trace.
	7	.13	.11	16.40	.29
	8	.20	.15	17.80	.93
	9	....	....	47.00	.46
Middle-sandstone soils[b]	1	.06	.05	.09	.06
	2	.05	.04	.05	.04
	3	.06	.07	.17	.19
	4	.06	.08	.19	.14
	5	.03	.02	.02	.02
	6	.09	.09	.00	.27
	7	.19	.05	.014	.08
	8	.17	.18	.25	.09
	9	.13	.34	.52	.15
North German plain loess[c]		2.33	....	6.6	1.37
		2.47	....	.59	.25
		.81	....	.50	.17
		2.58	....	.80	.72
		2.57	....	.43	.70
Highland		.109	.115	.064	.228
		.41	.06	.29	.64
		.026	.088	.072	.075
		.102	.03	.242	.181

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[a] Halenke, Kling and Engels, Vierteljahresscb. bayer. Landw.-Rat, 10, 447 (1905).

[b] Blanck, Landw. Vers.-Sta., 65, 161 (1906).

[c] Burguy, Über die Bödenverhältnisse des norddeutschen Flachlandes in ihrer Beziehung zum geologischen Aufbau desselben. Inaug.-Diss. Berlin, [illegible].

APPENDIX C.

WATER SOLUBLE CONSTITUENTS OF SOIL.

Locality, Salem, N. J. Soil type, Norfolk sand. Crop, wheat.

[Yield of crop, good.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
March 10	0-12	13.2	12	5	12
	12-24	11.5	7	5	16
June 8	1-24	4.3	4	14	13
June 13	1-24	4.6	5	13	17
June 19	1-24	9.6	2	14	24

Locality, Salem, N. J. Soil type, Norfolk sand. Crop, wheat.

[Yield of crop, poor.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
April 3	0-12	12	11	5	32
	12-24	12	10	3	22
June 16	1-24	9.3	4	29	20

Locality, Salem, N. J. Soil type, Sassafras loam. Crop, wheat.

[Yield of crop, medium.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
March 10	0-12	23.2	19	10	8
	12-24	21.6	11	10	14
March 14	0-12	22.3	18	8	18
	12-24	20.2	15	12	21
	24-36	20.3	18	17	16
March 20	0-12	19.3	7	10	21
	12-24	18.6	4	11	21
	24-36	12.6	5	12	21
June 16	1-24	22.5	4	24	23

Locality, Salem, N. J. Soil type, Sassafras loam. Crop, grass.

[Condition of crop, medium.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
March 10	0-12	25	13	28	18
	12-24	23.8	7	26	13
	24-36	19.9	16	8	15
March 14	0-12	25.8	21	12	21
	12-24	23.1	8	12	15
	24-36	21.8	9	15	21
March 31	0-12	23	11	23	43
	12-24	21.6	8	20	34
April 2	0-12	24.8	8	16	41
	12-24	24	6	21	38
	24-36	21.4	3	11	25

Locality, Salem, N. J. Soil, type, Sassafras loam. Crop, wheat.

[Yield of crop, good.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
March 17	0-12	22	8	6	10
	12-24	18.1	8	15	14
March 17	0-12	18.3	10	15	Lost.
	12-24	18.1	9	24	25
March 24	0-12	24.7	14	12	30
	12-24	22.3	8	11	33
March 26	0-12	23.4	4	16	16
	12-24	23.9	12	16	20
	24-36	22.4	8	3	21
April 2	0-12	25.6	8	16	30
	12-24	24.4	8	17	47
	24-36	21.6	8	11	38
June 5	0-12	5.2	14	51	23
	12-24	8	15	55	32
June 8	1-24	10.6	2	20	13
June 11	1-24	15.5	6	26	14
June 13	1-24	8.2	6	19	22
June 16	1-24	15	5	21	19
June 17	1-24	10.6	7	63	17

Locality, Salem, N. J. Soil type, Sassafras loam. Crop, clover.

[Yield of crop, medium.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
March 20	0-12	20.8	5	15	22
	12-24	20.2	5	15	27
	24-36	18.6	5	12	36
March 26	0-12	26.8	9	31	20
	12-24	22.9	8	20	13
	24-36	22.5	4	14	20
June 6	0-12	8.1	8	16	17
	12-24	12.7	9	18	20

Locality, St. Marys, Md. Soil type, Leonardtown loam. Crop, wheat.

[Yield of crop, good.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
April 27	0-12	21.8	5	10	12
	12-24	21.3	4	7	10
April 29	0-12	22.2	8	15	62
	12-24	21.8	4	11	38
May 1	0-12	22.4	7	14	23
	12-24	21.8	7	8	30
May 1	0-12	17	5	16	25
	12-24	21	5	7	19
May 9	0-12	15	13	34	29
	12-24	15.9	9	17	26
May 15	0-12	14.2	3	14	24
	12-24	19.9	4	13	23
August 14	0-24	15	6	11	13
August 15	0-24	15.7	5	3	17
August 15	0-24	16.4	8	15	15

Locality, St. Marys, Md. Soil type, Leonardtown loam. Crop, wheat.

[Yield of crop, poor.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
May 14	0-12	14.7	5	8	35
	12-24	19.9	4	4	30
May 23	0-12	7.8	4	7	22
	12-24	14.9	4	11	23
August 14	0-24	16	4	4	16
August 15	0-24	19.5	6	4	13

Locality, St. Marys, Md. Soil type, Leonardtown loam. Crop, corn.

[Yield of crop, good.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
May 8	0-12	18.2	9	12	29
	12-24	18.9	10	7	26
May 18	0-12	18.2	3	24	38
	12-24	18.8	6	19	28
August 8	0-24	17.5	7	30	18

Locality, St. Marys, Md. Soil type, Leonardtown loam. Crop, corn.

[Yield of crop, poor.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
May 23	0-12	16.6	5	12	22
	12-24	17.4	6	8	22
August 8	0-24	19.9	9	25	20
August 15	0-24	21.6	7	15	13

Locality, Statesville, N. C. Soil type, Cecil clay. Crop, clover.

[Yield of crop, good.]

Date.	Depth.	Moisture content.	Parts per million of oven-dried soil.		
			Phosphoric acid (PO_4).	Calcium (Ca).	Potassium (K).
	Inches.	*Per cent.*			
March 17	0-12	19.6	7	....	5
	12-24	20.9	13	....	6
March 17	0-12	24.7	16	....	5
	12-24	35.1	18	....	7
	24-36	30.7	22	....	10
March 17	0-12	20.2	10	....	5
	12-24	21.4	12	....	6
August 7	0-17	18.8	2	....	34
	0-24	30	24	....	....

COMMERCIAL FERTILIZERS AND FERTILIZER INSPECTION.

By Dr. MILTON WHITNEY,
Chief of Bureau of Soils, United States Department of Agriculture.

It has been shown in the discussion of "Crop Yields and Soil Composition" that there are three principal methods of control of soil fertility, a subject which is the very foundation of the material wealth of this nation and of its position among the countries of the world; these are cultivation, rotation of crops, and fertilization. Of these, the first two are in the hands of the farmer himself, and require only knowledge, intelligence, and skill in manipulation. Fertilizing materials, however, have, to a very large extent, to be gathered for him from different parts of the world and manipulated before they are ready to be applied to the land.

It was early found that unscrupulous manufacturers were ready to, and actually did, perpetrate gross frauds upon the farmers by selling worthless material for exorbitant prices.[a] The first practical method devised to meet the situation in this country was a voluntary agreement or understanding between the manufacturers, dealers, and farmers, to submit for analysis samples of all brands offered for sale or purchased in a State to some competent chemist in the agricultural society, state department of agriculture, or experiment station, as a final arbiter. Such an agreement was entered into in Connecticut in 1876, and the reasons for it and terms of agreement are given in an appendix of this article.[b] Subsequent to this, most of the States passed very strict and comprehensive fertilizer-control laws, which have worked admirably in preventing frauds, to the advantage alike of manufacturers and farmers. Broadly speaking, this regulation has been vested in the state experiment stations in the Northern States and in the state departments of agriculture in the Southern States, and is based upon the general policy of police regulations for the public good. Generally speaking, also, a fee is exacted from the manufacturers in the Northern States, based upon the number of valuable plant-food constituents (phosphoric acid, nitrogen, and potash) claimed to be present in the fertilizers, while in the Southern States, besides a fee for registration of brands, a tax of so much per ton is exacted, thus providing a considerable revenue for the State.

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[a] See transactions of the Connecticut State Agricultural Society for the year 1859, p. 41.

[b] Previous to this, however, the State passed a law making it mandatory for all manufacturers or dealers to affix a guaranteed analysis to each package of fertilizer, with certain exceptions, and authorizing the president of the State Agricultural Society to have analyses made at his discretion, and prosecute for frauds, under his judgment.

On account of the interstate character of the fertilizer trade, it has not been possible for the state authorities to maintain a factory inspection, and they have had to rely upon the guaranty of the manufacturer as to the nature of the material which has been put into the fertilizer (which statement is generally considered confidential), and upon their own analysis of samples picked up at random in the open market. This has, from the first, been recognized as a weak point in the present fertilizer-control system. The analysis is recognized as merely a commercial valuation, with little or no connection with the agricultural values of the fertilizer.

At first the inspecting officers determined merely the total amount of nitrogen, the water soluble potash, and the water and citric acid soluble phosphoric acid, and allowed a liberal value for each of these ingredients when contained in a mixture, based upon the assumption that only high-grade goods had been used by the manufacturer. The tendency in quite recent years, however, is for the inspecting officers to make more complete analyses, in an effort to show more about the origin of the materials in the mixtures. It is obviously impossible from any analysis, however complete, or from any microscopical investigation to determine with accuracy the character of the material that has been used, and the only method by which such information could be reliably placed before the purchasers would be by factory inspection, in which the kind and amount of material used in the mixture would be certified on the package and vouched for by the impartial inspector.

The reason for the beneficial effects of fertilizers has long been held[a] to be due to the supply of mineral plant food to the soil in a more soluble or available form than is found in soils of low productivity. That this is not the most important function of fertilizers has long been suspected by thoughtful men, who could not reconcile many well-known and obvious facts with this plant-food theory. Nevertheless, it was not until the investigations of the Bureau of Soils into the chemistry of the mineral portion of the soil, showing the remarkable constancy of composition of the soil moisture and demonstrating the reasons for this, that we were able to say conclusively that this is not the chief nor most important function of fertilizers. Not until the researches on the chemistry on organic matter in the soil had revealed the presence of toxic organic bodies, resulting from the growth of crops, and the analogy was seen with the metabolic processes of the animal body, and the processes for the elimination of the waste products so formed, did rational reasons for cultivation, crop rotation, and fertilizers become apparent, among others being the elimination of harmful waste products and the preservation of proper sanitary conditions in the soil. It was then evident also why the ordinary chemical analysis of the soil had failed to reveal the fertilizer requirements, and why different substances, having the same chemical ingredients, often have very different effects on soils and crops.

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[a] The use of commercial fertilizers is not old. The first lot of natural guano was imported into England in 1840, and nitrate of soda about 1830. The potash deposits of Germany were first worked in 1862. The phosphate deposits in South Carolina in 1868. Phosphates were discovered in Florida in 1888, and in Tennessee in 1894.

A great fertilizer trade, estimated at from $80,000,000 to $100,000,000, or approximately 1 per cent of the total value of our agricultural products, has been built up on the supposition that soils wear out and become exhausted of their available mineral food, and that it is necessary, in order to maintain the fertility of our soils, to bring nitrates from Chile, potash from Germany, and phosphates from certain deposits in this country in order to return to the soil the equivalent of what is removed by our crops.

That it is the material and not the element which determines the possible agricultural value of the fertilizer is becoming more and more evident every day. Most of the States prohibit the incorporation into commercial fertilizers of such substances as ground leather, horn shavings, feathers, hair, wool waste, or muck, although these are highly nitrogenous, because it is the general belief that they are ineffective when applied to the soil. It is not believed by competent persons that nitrate of soda, sulphate of ammonia, and the various organic forms of nitrogen commonly used in fertilizers are equally effective on all soils, crops, and in all seasons. Indeed, we have undoubted evidence that they may differ widely, and yet we apply them indiscriminately and without certain knowledge of what we are using in our commercial fertilizers. The same way with the materials furnishing phosphoric acid and, to a less extent, with potash. It is true that the inspecting officers of the various States are making more complete analyses in order to determine more nearly the nature of the materials in the mixture, to verify the statement of the manufacturers, but it is admitted that this is only approximate and incomplete. There is nothing accomplished by the present system of inspection which the factory inspection would not show much better, besides giving the certain information that we are purchasing nitrogen in the form of nitrate of soda, sulphate of ammonia, cotton-seed meal, tankage, and other forms, which information may be the means of insuring success and of establishing a rational system of fertilization which up to this time has not prevailed in this country. In the nature of the case the States can not maintain a general factory inspection, but the Federal Government can, as they do in meat inspection.[a] The chief objection to federal inspection has been that it would remove certain sources of revenue from the States, but there seems no valid reason why even with federal inspection the States can not still exact a fee from dealers and a tonnage tax on the amount sold in the State.

It has been stated above that there is no rational system of fertilization in general use in this country, and in this respect the United States appears to be far behind some European countries. We have, indeed, a general idea of the form of fertilizer material adapted to some of our soils and crops and some idea of the relation of soil conditions and climatic conditions to fertilizer action, but these ideas are not based upon exact facts and are not practically applied by our fertilizer manufacturers or farmers.

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[a] The Twelfth Census gives 422 fertilizer manufacturers in the United States.

The advice of our agricultural chemists and agronomists is almost universal that farmers should test their soils by plot experiments to determine the most efficient forms and combinations of fertilizers. Such experiments are costly and take time, and results vary with different seasons. Such of our experiment stations as have carried on these fertilizer tests hesitate to draw conclusions with less than an average of ten years. One of the most recent of the standard books on fertilizers[a] asserts in the most cautious way and with many qualifications that corn is particularly responsive to phosphates, cereal crops to nitrates, grasses and clovers to phosphoric acid and potash, beets and carrots to nitrogen, potatoes and sweet potatoes to potash, and truck crops to nitrogen, and yet with only this meager information, not pretending to be exact or invariable, we find a multitude of brands on the market, many of them being prepared and recommended for special crops. One has but to look up the reports of the departments of agriculture and state experiment stations charged with the inspection of fertilizer materials to see the absolute lack of system which prevails in the fertilizer trade. The tendency in this country seems to be to increase the number of special brands for special crops, but there is an absolute lack of uniformity, even in the elementary composition of these special brands.

As a rule, the fertilizer formulæ are simpler and more uniform in the South than in the North, and there are also a less number of special brands for special crops. For example, there are very few fertilizers for special crops offered in the States of Alabama and Georgia. In North Carolina about 28 per cent of the whole number of brands of fertilizers sold in the State are recommended for special crops. In Connecticut 45 per cent of the whole number of brands sold are special brands for special crops. In the State of Georgia there were 1,822 brands inspected, analyzed, and placed upon the market for sale in 1908. Of these, 1,260 brands contained two or more of the plant-food elements (phosphoric acid and nitrogen or potash) in 106 different combinations, as shown on the guaranties; 1,143 of these brands, or 90 per cent, contained 6 or more identical guaranties covered by 26 combinations; there were 255 brands, or 27 per cent, of the complete fertilizers which contained 10 per cent of phosphoric acid, 2 per cent of ammonia, and 2 per cent of potash. There were 242 brands, or 26 per cent, which contained 8 per cent of phosphoric acid, 2 per cent of ammonia, and 2 per cent of potash. If these brands differ in the material of which they are composed, the farmers should know it to enable them to make a more intelligent selection for their particular soils and crops, but there is no way in which they can find out whether the brands differ or not. It is also to the interest of the manufacturer to have this known. The brands undoubtedly differ in effectiveness by reason of the materials which they contain, and we are sadly neglecting our opportunities of developing agricultural practice by failure to know the material these fertilizers actually contain. Of the 33 special brands for tobacco placed on sale in the State of Connecticut, phosphoric acid ranges from 3 to 9 per cent, ammonia from 2 to 7¼ per cent, and potash from

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[a] Fertilizers, by Edward B. Voorhees, 1902.

2 to 11 per cent; there are 24 different combinations in the 33 brands issued for this very limited crop in Connecticut. Instances of this kind could be multiplied almost indefinitely, and it is considered best to submit with this report an appendix giving a very complete analysis of the figures relating to the fertilizers on sale in three of the Southern States (Alabama, Georgia, and North Carolina) where the fertilizer control is under the state departments of agriculture, and in three of the Northern States (Maine, Massachusetts, and Connecticut) where the fertilizer control is vested in the state experiment stations.

Most of the States regulate by law, or by executive order under authority of law, material which may or may not be used in commercial fertilizers and the words which may be printed or stamped on the brands. Thus the State of Georgia prohibits the use of the word "standard" in connection with a brand containing less than the commercial equivalent of 8 per cent of phosphoric acid, 2 per cent of ammonia, and 2 per cent of potash; and of the words "high grade" on any fertilizer containing less than the commercial equivalent of 10 per cent phosphoric acid, 2 per cent ammonia, and 2 per cent potash, although both of these combinations are far below the combinations recommended by the state department of agriculture for crops.

It is the general belief at the present time that a fertilizer for tobacco should be rich in potash, and that for cigar tobacco the potash should be in the form of carbonate, yet we find in Connecticut special brands for tobacco with from 1 to 3 per cent of potash, and so far as the evidence permits one to judge the potash in the majority of brands is not in the form of carbonate. It would seem that it would be possible by law, and a protection to the farmers, to prohibit the use of the word "tobacco" on a brand of fertilizer containing less than 6 per cent of potash, to be contained in the form of carbonate only.

It is the general belief that potatoes require fertilizers rich in potash, and that it is better to have the potash in the form of sulphate, yet we find brands of special fertilizers for potatoes offered for sale in Maine with only 2 and 3 per cent of this ingredient. In this case also it should be possible under the law, and a protection to the farmers, to prohibit the use of the word "potatoes" on any special brand for potatoes with less than a minimum of, say, 6 per cent of potash, and this in the form of sulphate only.

It is believed and taught by the Maine Experiment Station[a] that nitrogen for potatoes should be in the form of nitrate nitrogen, and yet even in that State the principle is not enforced by law, and the nitrogen supply in special fertilizer brands for potatoes is of such form as may be determined by the manufacturer. It is the general belief that sugar beets require a fertilizer rich in potash, and that it is best to have this in the form of chloride or muriate; but no particular attention seems to be paid to this in the preparation of special brands, and farmers do not know what materials they are purchasing, and can not know with the best system of inspection which is being maintained by any State.

Instances could be multiplied indefinitely where our practice does not conform even to our present best knowledge.

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[a] Bul. 153, Maine Agr. Expt. Sta., March, 1908, p. 105.

The only conclusions that can be arrived at from the study of this material are—

That the form of inspection that has prevailed in the past is inadequate for the growing needs of the farmer for more definite and more explicit information in regard to the composition of the materials going into the commercial fertilizers, and that proper inspection can only be made by the Federal Government on account of the interstate character of the fertilizer trade.

That there is no rational system of fertilization in this country, and although we have an enormous trade in fertilizing material, it is absolutely necessary that the whole question of the effective composition of fertilizers be investigated in order to work out the most effective and most efficient system of fertilization.

And that our knowledge of the requirements of special fertilizers for special soils and crops is wholly inadequate to the needs of our people, and the subject requires a thorough and complete investigation in order that we may use our valuable fertilizing materials to the best advantage, making this method of the control of soil fertility of the higest efficiency. The time has come when we begin to know something of the true principles of fertilizer action and when the methods of investigation are adequate to solve this very intricate problem, which has grown to enormous proportions upon no adequate knowledge or basic efforts to insure the success which we should reasonably expect.

APPENDIX A.

EXTRACTS FROM OFFICIAL REPORTS AND STANDARD BOOKS ON FERTILIZERS.

The following extracts do not pretend to be a complete résumé of the literature on fertilizers, as the subject is very voluminous, but only to give a few striking statements from recognized authorities on the points which have been made in the preceding report:

In its work in connection with commercial fertilizers, in detecting and driving out frauds, placing the trade on a rational basis, encouraging honest manufacturers and sellers, and teaching farmers how to select their fertilizers wisely and use them with profit, its [the experiment station's] usefulness can not be overestimated. (First Annual Report, Conn. Agr. Expt. Sta., 1876, prefatory note, p. 3.)

The means adopted by the station to regulate the sale of fertilizers in the State has been explained quite fully in Circular No. 4 of the station. * * * The plan is substantially the same as has, with various modifications of detail, come into quite general usage in Germany and other European countries. The essential features are:

First. An agreement made with the station by dealers in fertilizers to sell their wares by guaranteed analysis, the verification of the analysis being left to the station; and

Second. A provision whereby purchasers may have samples of the articles they buy analyzed by the station at small cost or for nothing.

In order to preclude all chance for mistake or cavil as to the precise terms of the arrangement referred to a form of agreement has been signed by the dealers who desired to place their wares, as sold in the State, under the supervision of the station.

The form referred to is the result of deliberations of a large meeting of manufacturers, sellers, and consumers of fertilizers held at the station and of consultation with the advisory committee and with other parties interested. It is as follows:

BLANK B.

------ hereby agree with the Connecticut Agricultural Experiment Station, as represented by its directors, that all fertilizers offered for sale in the State of Connecticut by ------ or by ------ authorized agents, at any price above $15 per ton, except crude fish scrap, shall be placed under its supervision in the following manner:

1. ------ hereby agree that all fertilizers above described shall be guaranteed to contain certain minimum percentages of one or more of the following ingredients:

   Nitrogen.
   Phosphoric acid; soluble.
   Phosphoric acid; reverted.
   Phosphoric acid; insoluble.
   Potash.
   Sulphuric acid; chlorine.

2. ------ also agree that the above guarantee shall be always subject to verification by analyses made at the stations.

3. ------ also agree that all fertilizers above described shall be at all times open to the inspection of the station, as represented by its director, chemists, or any member of its advisory committee. * * *

The signer of this agreement is not expected to specify in this blank the composition of the wares he sells, but he does bind himself to fulfill the requirements of the state law, by accompanying every package of fertilizer sold with a plain statement of the analysis, using the above terms, and to guarantee the article to be equal to the analysis.

In brief, this statement binds the signer simply to state what he sells and guarantees what he states, the verification of the statement being left to the official analysis of the station. With the fulfillment of this guarantee the responsibility of the seller will naturally end. The station provides that buyers who wish to determine whether the articles they purchase are equal to the guarantee, may have control analyses made at little or no expense. It is believed that no simpler nor more efficient way can be devised to place the trade in fertilizers on a more secure basis, insure confidence, and benefit all concerned. (First Annual Report, Conn. Agr. Expt. Sta., 1876, pp. 14–16.)

The question as to which is the most serviceable and best fertilizer is like the question, Which is the best and most serviceable medicine?—impossible to answer. All depends on the patient, on what ails him, and on how he is being treated otherwise.

The experiment station might be compared to a sanitary engineer, but not to a practicing physician. We are unable to prescribe for land. The only way is for the practical farmer to make trials on his land with fertilizers or fertilizing chemicals which he knows are of good quantity (quality?) and study the effects. * * *

There is a choice also in respect to action on the crop. This will depend somewhat on the character of your soil and can only be learned by experience. One fertilizer will appear to be best one year or on some crops and land, and another season, owing to the different weather, wet or drought, or on other land or plants another kind of fertilizer will give the best results. I should try a fertilizer that would give me a good percentage of nitrogen, soluble phosphoric acid and potash, for the least money.

We can give no formula for an onion manure. The food which the onion requires is the same that all other crops require. If it requires any special proportions of fertilizing ingredients, neither we nor anyone else can positively say what that is. Probably a fertilizer having about the composition of the "special" onion, potato, tobacco, or corn manures would be as profitable a fertilizer as you could apply to the onion. * * *

It is a fact of common farm experience that nitrogenous manures differ widely in their efficiency. Nitrate of soda, for example, often has a visible effect on grass land within ten days after sowing; dried blood requires a longer time to affect the color or growth of grass, while an application of leather or hair may never show the slightest effect. * * *

A considerable number of manufacturing wastes, rich in nitrogen, but differing greatly in their values as plant foods, are now on the market, and their use is urged upon manufacturers of mixed fertilizers. In general, such of these waste products as are agriculturally of least value are also least expensive, and therefore the temptation to use them in manufactured goods is to some very strong.

It is highly desirable to know in the first place how these nitrogenous wastes compare with each other, and with some standard, such as nitrate of soda in availability and various experiments have already accomplished something in this direction. In the next place it is important, either to be able to identify these various "ammoniates" and mixed fertilizers or else to have some means of distinguishing in such fertilizers between available and inert nitrogen; some measure of its availability. Unfortunately it has hitherto been difficult or impossible to identify with certainty most of the inferior ammoniates, either by inspection or by ordinary chemical tests. The treatment with acid during the process of manufacture, the grinding, and the mixture with phosphatic material and potash salts so alters the structure and appearance that in many cases the microscope fails to identify anything and chemical tests are not generally applicable. (Annual Report Conn. Agr. Expt. Sta., 1885, pp. 110–115.)

We have reason to believe from extended observations and experience in the field that hundreds of thousands of dollars are annually wasted by farmers in the lavish and injudicious application of fertilizers on cotton. The author shows that the different forms of phosphates and the different materials used to supply nitrates vary greatly in their efficiency. (Fertilizers for Cotton, J. M. McBryde, Farmers' Bulletin 14, 1894, p. 7.)

"The most satisfactory, and, indeed, usually the only method," says Armsby, "by which we can at present determine the needs of a soil is to ask the question of the soil itself by growing a crop upon it with different kinds of fertilizers and noting the result. Such soil tests with fertilizers have in many cases given results of which immediate practical value for the locality in which they were undertaken."

Many materials containing the essential elements are practically worthless as sources of plant food because the form it not right. * * * All materials containing organic nitrogen are valuable in proportion to their rapidity of decay or change. * * * Thus organic nitrogen differs in availability not only according to the kind of material which supplied it, but upon the treatment it receives. * * * The phosphoric acid in natural or untreated phosphates is insoluble in water and not readily available to plants; that is, the rate of availability depends largely upon the rapidity with which the substance rots or decays, and the rate of decay again depends upon the character of the substance with which the phosphate is associated. * * * Potash may exist in a number of forms, though chiefly as chlorids, or muriates, in which case the potash is combined with chlorin; and as sulphates, in which the potash is combined with sulphuric acid. With potash, however, the form does not exert so great an influence upon availibility as is the case with nitrogen and phosphoric acid. All forms are freely soluble in water, and are believed to be nearly if not quite equally available as food. The form of potash has, however, an important influence upon the quality of certain crops, due rather to the constituents with which the potash is associated than to the potash itself. * * * The character or form of the material used must therefore be carefully considered in the use of manure. * * * All manufacturered products or brands of fertilizers are made up of a mixture of the various kinds and forms of fertilizing materials just described, and the differences that exist in the brands of different manufacturers are due both to differences in the character and to the variations in proportions of the materials used to form the different brands; that is, while all manufacturers must go to the sources of supply indicated, they may select either good or poor products and may vary the proportions of the different materials used.

The difference between a good brand of fertilizer and a poor one lies not so much in differences that may exist in the total amount of plant food contained in it as in the quality of the materials of which it is made. (Commercial Fertilizers, Farmers' Bulletin 44, Edward B. Voorhees, 1896.)

The following extracts are from Fertilizers, by Edward B. Voorhees, originally published in 1898, with a fourth edition in 1902:

Preface: There is no question as to the desirability of the use of commercial fertilizers on most farms, though the methods now generally practiced are such as to indicate the very great need of a better understanding of what the functions of a fertilizer are, of the terms used to express their composition and value, of the kind that shall be used, and the time and method of application for the different crops under the varying conditions that exist. * * * The author appreciates keenly his limitations, owing to the lack of definite knowledge on many vital points; yet it seems that at this time, when the investigations of the experiment stations are beginning to be regarded as important educational factors, and when these institutions are more than ever prepared to study the fundamental principles which underlie the various processes involved in plant nutrition, the practical man should have a clear understanding of what is now known, in order that he may be prepared to accept and use that better knowledge which will undoubtedly be provided for him in the near future.

Page 49: It will be observed from the foregoing brief description of the chief sources of organic forms of nitrogen that a very wide variation occurs both in the composition or content of nitrogen in these products and in the availability of their nitrogen, or rapidity with which, under similar conditions, it is given up to plants. The fact that a substance contains nitrogen in considerable amounts and in an organic form, then, is not a sufficient guide as to its usefulness.

Pages 54–57: The practical point, and the one of prime importance to the farmer, is, then, to know how to estimate the relative value or usefulness of these different products, what is the rate of availibility as compared with nitrate, and thus the relative advantage of purchasing the one or the other at the ruling market prices. Relative values, however, can not be assigned as yet, though careful studies of the problem have been made, chiefly by what are known as "vegetation tests," that is, tests which show the actual amounts of nitrogen that plants can obtain from nitrogenous products of different kinds when they are grown under known and controlled conditions. The results so far obtained, while only serving as a guide, indicate that when nitrate is rated at 100 per cent, blood and cotton-seed meal are about 70 per cent, dried and ground fish and hoof meal 65 per cent, bone and tankage 60 per cent, and leather, ground horn, and wool waste range from as low as 2 per cent to as high as 30 per cent. These figures furnish a fair basis for comparing the different materials when used for the same purpose or under the same conditions. If, for example, the increased yield of oats due to the application of nitrate of soda is 1,000 pounds, the yield from blood and cotton-seed meal would be 700 pounds, the yield from dried ground fish and hoof meal would be 650 pounds, from bone and tankage 600 pounds, and from leather, ground horn, and wool waste, from 20 to 300 pounds.

These figures alone are, however, not a sufficient guide as to the kinds to buy under all conditions, since the usefulness of the different forms are again dependent upon such other conditions as the kind of crop, the season, and the object of the application. * * * In the making up of fertilizers, all of these considerations should be carefully balanced, and it is the practice on the part of many manufacturers to use a part of each of the three forms, so that a continuous feeding of the plant may be insured. Therefore, while the fact remains that fertilizers containing only the one form may not be the poorest, the chances are that those which contain all forms are likely to give more satisfactory results.

Pages 92–94: It [potash] is, however, a very necessary constituent of fertilizers, being absolutely essential for those intended for light, sandy soils and for peaty meadow lands, as well as for certain potash-consuming crops, as potatoes, tobacco, and roots, since these soils are very deficient in this element, and the plants mentioned require it in larger proportions than do others. * * *

Potash, as has already been stated in the discussion of phosphoric acid and nitrogen, exists in various forms, but it differs from the other elements in that its chemical form or combination seems to exert but relatively little influence upon the availability of the constituent. For example, it may be in a form of muriate or chlorid, of a sulphate or of a carbonate, and while there is a difference in the diffusibility of these different compounds—that is, a difference in the rate at which they will distribute in the soil before becoming fixed—there seems to be very little difference in the rate of the absorption of the potash by the plant. Nevertheless, the form of potash must be observed, because of the possible influence that the substances with which it combines may exert in reducing the marketable quality of the crop to which it is applied. This influence has been very distinctly observed, particularly in the growing of tobacco, sugar beets, and potatoes, and it has been shown that the potash in the form of a chlorid (or muriate) does exert a very deleterious effect, especially on tobacco.

Pages 129–130: In the purchase of mixtures consumers should demand that they be accompanied by a guaranty, because they are unable to determine the kind and proportion of the different materials entering into the mixture, either by its appearance, weight, or smell. In mixing, too, an opportunity is afforded for disguising poor forms of the constituents, particularly nitrogen; that is, in a mixture of nitrogeneous materials, potash salts and superphosphates, it would be a difficult matter to determine, by mere physical inspection, the proportion of the nitrogen which had been supplied in the form of horn meal and of blood, and the statement of the manufacturer on this point would be valuable in proportion to his reliability.

Page 149: An analysis may show simply the total amount of the constituent. This is not a sufficient guide as to the value of the mixture, for while it is not possible to indicate absolutely by analysis whether the organic nitrogen, for example, is derived from blood (which is one of the best forms), or from horn meal (one of the poorer forms), it is possible to show whether the nitrogen is derived from nitrate of from ammonia; whether the phosphoric acid is derived from a superphosphate or a phosphate, and whether the potash present is in the form of a sulphate or of a muriate. A high-grade or a low-grade fertilizer, for example, may be distinctly indicated by the analysis, since it is of a high grade if the three forms of nitrogen are present, if the total phosphoric acid is chiefly soluble in water, and if the poash has been derived from a sulphate or from a muriate.

Page 152: It is obvious, from what has been already pointed out, that the value of a fertilizer to the farmer depends not so much upon what is paid for it as upon the character of the material used to make it.

Page 175: A ton of wheat at $1 per bushel, will bring $33.33. Its sale removes from the farm 38 pounds of nitrogen, 19 of phosphoric acid, and 13 of potash. At prevailing prices for these constituents it would cost $6.50 to return them to the farm.

Pages 158–161: It will be observed that the schedule gives the cost per pound of the different forms of nitrogen and of high-grade organic nitrogenous materials; of nitrogen and phosphoric acid in ground bone and tankage; or available phosphoric acid in superphosphates, and of the actual potash in potash salts, and is a useful guide also in showing that the nitrogen, phosphoric acid, and potash contained in these materials can be purchased in ton lots for the prices mentioned. The valuation of mixed fertilizers, obtained by the use of this schedule, are entirely commercial; they are not intended to indicate even a possible agricultural value. * * *

Third. The chemical analysis does not show absolutely the sources of the materials, and thus it is difficult to place a true commercial value upon a mixture. This is especially true of organic nitrogen, derived from different materials, a uniform value is placed upon the total nitrogen found, whether it is derived from the best forms, as dried blood and dried meat, or whether derived from horn meal, ground leather, or other low-grade forms of nitrogenous materials. This encourages the use of low-grade products by unscrupulous manufacturers to the real detriment of the trade as a whole. * * *

Fourth. Any system of comparison of brands must leave a great deal to the judgment of the purchaser. He must interpret for himself whether he would rather that his phosphoric acid were derived from one source or another.

Page 167: The primary object in the use of a commercial fertilizer is to receive a profit from the increase in the yield of crops from the land to which it is applied; and this may be derived either from the immediate crop or from the larger yield of a number of crops. That the greatest immediate and prospective profit may be gained, a wide knowledge of conditions which have either a direct or indirect bearing upon the result is essential.

In fact, the controlling conditions surrounding the matter are so numerous and so various that it is impossible, with our present knowledge, to lay down positive rules for our guidance. At best, only suggestions can be offered.

Page 172: It must be remembered, then, that only general rules apply in the use of fertilizers upon soils of different classes, and that they are modified by both the chemical composition and the mechanical condition of the soil. The best use of a fertilizer—that is, the greatest proportionate return of plant food in the crop, all things considered—is obtained from its application upon soils that possess "condition" or that are well cultivated or managed. Full returns can not be expected when they are applied upon soils that are too wet or too dry, too porous or too compact, or too coarse or too fine. It is important that even the best soils should be properly prepared, and it is infinitely more important that those which possess poor mechanical condition should be improved in this respect, before large expenditures are made for fertilizers.

Pages 182–185: The one system of fertilization which has perhaps received the most attention, doubtless largely because one of the first presented, and in a very attractive manner, is the system advocated by the celebrated French scientist, George Ville. This system, while not to be depended upon absolutely, suggests lines of practice, which under proper restrictions may be of very great service. In brief, this method assumes that plants may be, so far as their fertilization is concerned, divided into three distinct groups. One group is specifically benefited by nitrogenous fertilization, the second by phosphatic, and the third by potassic; that is, in each class or group, one element more than any other rules or dominates the growth of that group, and hence each particular element should be applied in excess to the class of plants for which it is dominant. In this system it is asserted that nitrogen is the dominant ingredient for wheat, rye, oats, barley, meadow grass, and beet crops. Phosphoric acid is the dominant fertilizer ingredient for turnips, Swedes, Indian corn (maize), sorghum and sugar cane; and potash is the dominant or ruling element for peas, beans, clover, vetches, flax, and potatoes. It must be understood that this system advocates only single elements, for the others are quite as important up to a certain point, beyond which they do not exercise a controlling influence in the manures for the crops for the three classes. This special or dominating element is used in greater proportion than the others, and if soils are in a high state of cultivation, or have been manured with natural products, as stable manure, they may be used singly to force a maximum growth of the crop * * *.

Another system which has been urged, notably by German scientists, is based upon the fact that the mineral constituents, phosphoric acid and potash, form fixed compounds in the soil, and are, therefore, not likely to be leached out, provided the land is continuously cropped. They remain in the soil until used by growing plants, while the nitrogen, on the other hand, since it forms no fixed compounds and is perfectly soluble when in a form useful to plants, is liable to loss from leaching. Furthermore, the mineral elements are relatively cheap, while the nitrogen is relatively expensive, and thus that the economical use of this expensive element, nitrogen, is dependent to a large degree upon the abundance of the mineral elements in the soil. It is therefore advocated that for all crops and for all soils that are in a good state of cultivation, a reasonable excess of phosphoric acid and potash be applied, sufficient to more than satisfy the maximum needs of any crop, and that the nitrogen be applied in active forms, as nitrate of ammonia, and in such quantities and at such times as will insure the minimum loss of the element and the maximum development of the plant.

Page 186: Another system of fertilization is based upon the theory that the different plants should be provided with the essential elements in the proportions in which they exist in the plants, as shown by chemical analysis. Different formulas are, therefore, recommended for each crop, the constituents of which are so proportionate as to reach its full needs. This method, if care is taken to supply an abundance of all of the necessary constituents, may result in a complete though, perhaps, not an economical feeding of the plant, since it assumes that a plant which contains a larger amount of one constituent than of another requires more of that constituent in the fertilizer than of the others. It does not take into consideration the fact that the plant which contains a larger amount of one element than another may possess a greater power of acquiring it than one which contains a smaller amount.

Pages 189–190: The most expensive and irrational system of all, and one more commonly practiced than any other in general farming, may be termed that "hit or miss" system; if a "hit" is made there is a profit, if a "miss" the loss is trifling. In this system, no special thought is given to the character of the crop or its needs. If the farmer can afford it, he purchases a fertilizer, without regard to its composition, and applies it in very small amounts. If it happens to contain that element which is particularly needed for the plant to which it is applied, a profit is secured. In too many cases, however, the constituents added are already in abundance in the soil, or so little of the fertilizer is used as to preclude any profit.

Page 193: The lacking element can not be fully determined, except by direct experiments by the farmer himself. That is, no general principle can be depended on as an absolute guide. He should learn whether his soil is deficient in any of the elements, and, if so, which one should be applied to the different crops in his rotation. A careful study along this line, too, will show whether it is fertilization that is required to meet seeming deficiencies, for it frequently happens that the needs of the soil are not so much for added plant food as for better management of the soil in other respects.

Pages 197–198: The results of experiment which have been conducted with great care in a number of States show that where "extensive" methods are practiced certain elements need not be added in the fertilizers; that is, that the soil contains such an abundance of them that the plant is able to obtain a full supply, at least, for a long time. For example, it has been shown that on the chief sugar-producing soils of Louisiana and Mississippi, and on the cotton soils of Georgia and Texas, the addition of potash has been of less importance in the past than the other elements, and it frequently does not need to be included in the fertilizer, while phosphoric acid is always needed.

The results of field experiments on this plan in New Jersey, on reasonably good, loamy soils, indicate that phosphoric acid and potash are of much more importance in fertilizers for corn than nitrogen; whereas upon sandy soils nitrogen and potash are of relatively more importance than phosphoric acid; that is, even where "extensive" practice is used there are conditions where one or more of the elements are not required in order to secure maximum crops, which eliminates the necessity of an immediate outlay for those constituents that are not lacking. Where experiments of this sort have been carried out and the specific needs determined, it becomes necessary to assume that all of the constituents are required, and to apply the amounts and proportions of those which the general considerations of the soil, season, climate, and crop would seem to demand.

As already pointed out, the methods of fertilization here suggested, though in many instances apparently positive, are not to be interpreted as absolute rules, but rather to be used as guides, based upon the best information that it has been possible to obtain, both as a result of scientific inquiry and of practical experience.

Pages 211–212: The main point in this whole matter of fertilization is to understand that a fertilizer is a fertilizer because of the kind and form of plant food contained in it; and that its best action, other things being equal, is accomplished when the soil possesses good physical qualities, when the management is also good, and when systematic methods are planned and adopted. "Hit or miss" fertilization, even for these crops, may pay, and doubtless on the average does pay, as well as some other things that farmers do, but does not pay as well as it might if better methods were used.

APPENDIX B.

A SUMMARY OF THE GUARANTEED ANALYSES OF FERTILIZERS SOLD IN SEVERAL STATES.

In this review or analysis of the figures showing the composition of the brands of fertilizers sold in the several States, the guaranteed minimum compositions only are used, as these are usually expressed in whole numbers or even percentages, and as they in most cases agree very well with the amounts found by analyses. The figures for nitrogen occurring in some of the reports have been calculated to ammonia (NH_3) for purposes of comparison, and in a few cases small fractions of a percentage have been neglected and the result stated in the nearest whole number. None of the remarks or observations made in connection with the figures have been quoted from the official publications.

CONNECTICUT.[a]

During 1907 thirty-six individuals or firms have entered for sale in this State 279 brands of fertilizers, viz:

Special manures for particular crops	126
Other nitrogenous superphosphates	98
Bone manures and "bone and potash"	23
Fish, tankage, castor pomace, and chemicals	32
Total	279

Classification of the fertilizers analyzed.

1. Containing nitrogen as the chief active ingredient:
    Nitrate of soda.
    Sulphate of ammonia.
    Dried blood.

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[a] Biennial Report, Conn. Agr. Expt. Sta., 1907–8.

1. **Containing nitrogen as the chief active ingredient—Continued.**
    - **Cotton-seed meal.**
    - **Castor pomace.**
    - **Linseed meal.**
2. **Containing phosphoric acid as the chief active ingredient:**
    - **Dissolved phosphate rock.**
    - **Basic slag.**
    - **Precipitated bone.**
3. **Containing potash as the chief active ingredient:**
    - **Carbonate of potash.**
    - **High-grade sulphate of potash.**
    - **Double sulphate of potash and magnesia.**
    - **Muriate of potash.**
    - **Kainit.**
4. **Containing nitrogen and phosphoric acid:**
    - **Bone manures.**
    - **Slaughterhouse tankage.**
    - **Dry ground fish.**
5. **Mixed fertilizers:**
    - **Nitrogenous superphosphates.**
    - **Special manures.**
    - **Home mixtures.**
6. **Miscellaneous fertilizers and manures:**
    - **"Vegetable potash."**
    - **Cotton hull ashes.**
    - **Wood ashes.**
    - **Lime and limekiln ashes.**
    - **Others, miscellaneous.**

Commercial valuations allowed by the station.

	Cents per pound.
Nitrogen in nitrates	18½
ammonia salts	17½
Organic nitrogen in dry and fine ground fish, meat, and blood, and in mixed fertilizers	20½
fine bone and tankage	20½
coarse bone and tankage	15
Phosphoric acid, water soluble	5
citrate soluble	4½
of fine ground bone and tankage	4
of coarse bone and tankage	3
of cotton-seed meal, castor pomace, and ashes	4
of mixed fertilizers, if insoluble in ammonium citrate	2
Potash as high-grade sulphate in forms free from muriate (or chlorids)	5
as muriate	4½

Composition of nitrogenous superphosphates summarized.

Phosphoric acid.		Ammonia.		Potash.	
Number of brands.	P_2O_5.	Number of brands.	NH_3.	Number of brands.	K_2O.
	Per cent.		*Per cent.*		*Per cent.*
2	10	2	8	9	10
17	9	2	7	1	8.8
34	8	1	6	4	8
14	7	9	5	13	7
20	6	2	4.5	13	6
6	5	17	4	4	5
7	4	2	3.5	2	4.5
		34	3	16	4
		8	2.5	1	3.8
		6	2	2	3.5
		2	1.5	6	3
		15	1	1	2.5
				24	2
				2	1.5
				2	1

Composition of nitrogenous superphosphates.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	10	3	2.5	1	7	6	6
1	10	2.5	3.5	1	7	5	5
1	9	4	6	1	7.5	4.5	10
2	9	3.5	4.5	1	7.5	4.5	8.8
2	9	3	8	2	7	4	7
1	9	3	4	1	7	1	2
7	9	3	2	1	7	1	1
1	9	2.5	2	1	6.5	8	2
1	9	1.5	2	2	6	7	5
2	9	1	2	1	6	6	6
1	8	5	7	2	6	4	10
5	8	4	7	1	6	4	7
1	8	4	6	3	6	4	6
4	8	3	6	3	6	3	10
6	8	3	4	1	6	3	8
2	8	2.5	3	1	6	3	7
1	8	2.5	1.5	2	6	3	2
1	8	2	3	2	6	2.5	2
3	8	2	2	1	6	1.5	3
1	8	1	5	1	5	4	4
3	8	1	4	2	5	3	3
1	8	1	3.5	1	5	3	10
3	8	1	2	1	5	2	4
1	8	1	1.5	1	5	1	2
1	8	1	1	1	4	5	6
1	7	8	10	1	4	4	3.8
1	7	5	10	3	4	3	4
1	7	5	8	1	4	2.5	6
3	7	5	7	1	4	2	4

Composition of special brands for tobacco.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	9	3	2	1	6	5	1
1	8	4	5	2	6	4	6
2	8	4	4	1	6	3	10
1	8	3	3	1	5	7	10
1	8	2.5	6	2	5	5.5	5
2	8	2.5	3	1	5	3.5	7
1	8	2	4	1	4	7	10
1	7	6	10	1	4	6	6
2	7	5	6	2	4	5	5
1	7	4	8	1	4	4.5	3
2	6	7.25	9	4	3	5.5	5
2	6	6	11	1	3	5	5

Composition of special brands for potatoes.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	9	2	5	1	7	4	7
1	9	2	2	1	7	4	6
1	8	4.5	6	1	7	2	6
4	8	4	7	2	7	2	4
1	8	3.25	7	1	7	1.5	2
2	8	3	7	1	7	1	3
3	8	3	6	3	6	4	10
1	8	3	5	2	6	4	6
1	8	3	4	4	6	3	5
3	8	2.5	6	1	6	2.5	4
4	8	2.5	3	1	6	2	4
4	8	2	10	1	5	2	10
1	8	2	4	1	5	2	6
1	8	2	3	1	4	4	8
1	7	6	5	1	4	1	8
1	7	4.5	8				

Composition of special brands for corn, grain, and grass.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	10	4	7	1	7	2	2
2	9	3	2	1	7	1.5	2
1	9	2	5	1	6	5	5
1	8	6	8	1	6	4.75	2
1	8	3	6	1	6	4.25	7
1	8	3	4	1	6	4	6
4	8	2.5	1	1	6	2.5	12
1	8	2	5	1	6	2	3
1	8	2	3	1	5	6	2
3	8	2	2	1	4	6	6
2	7	7.5	7	1	4	6	2
1	7	5	7	1	4	3.5	5
1	7	5	6	1	3.9	10.25	8

MASSACHUSETTS.

The following explanatory statement is taken from the official bulletin, giving the results of the fertilizer inspection for the season of 1907:[a]

The organic nitrogen in the mixed goods is valued as coming from the best grade of raw materials and is counted at 20½ cents per pound. This method of valuing the organic nitrogen in mixed fertilizers will, of course, give a too high value on those goods in which the organic nitrogen has been derived from low-grade materials which possess slowly available nitrogen. This seems to be the only course, however, at present, as the ordinary methods of analysis will not discriminate between the available and inert forms of organic nitrogen.

Soluble phosphoric acid is valued at 5 cents per pound, citrate soluble or reverted acid at 4½ cents, and the phosphoric acid which is insoluble in ammonium citrate (usually termed insoluble phosphoric acid) at 2 cents per pound. Potash is valued according to the form in which it is found present in the fertilizer. Whenever a potash test is reported in the tables without comment or footnote, it will be understood that sufficient chlorine was present to unite with all of the potash. Every brand of complete fertilizer is tested for chlorides, and if sufficient chlorine is found to unite with all of the potash, it is taken for granted that the potash exists in the form of muriate and is counted as worth 4¼ cents per pound. The presence of chlorine does not necessarily prove that it is in combination with the potash, but its presence in a fertilizer supposed and advertised to be free from chlorides or where the potash is said to be present as sulphate or carbonate is just as objectionable as though it was actually in combination with the potash. Whenever the potash is guaranteed to be present as sulphate and the analysis shows the presence of chlorine, a footnote has been used to indicate how much is present in each form. Wherever only very small quantities of chlorides are present the potash has been reported as sulphate. Potash in form of sulphate has been valued at 5 cents per pound.

Whenever the potash is guaranteed as carbonate a test has been made for chlorides and sulphates, and a footnote indicates how much potash is present in each form. Potash in form of carbonate has been valued at 8 cents per pound.

Whenever it was known that potash had been derived wholly or in part from organic sources, in mixed fertilizers, a total potash test has been made and will be found reported in a footnote. No attempt has been made to place a valuation on that portion of the potash which is insoluble in water. It no doubt has a commercial value, but as we have no basis for establishing its worth, the results have simply been reported without comment. It should not be understood that all of the potash in vegetable organic compounds is insoluble in water. As a matter of fact about 80 per cent of the potash in cotton-seed meal is recovered in a water-soluble potash test. * * *

The agricultural value of a fertilizer represents its crop-producing power, which is far from constant on all soils.

The beneficial effect of any fertilizer on a particular soil depends on whether the fertilizer in question contains those elements of plant food in suitable quantity and quality in which the soil is deficient. In other words, the supply of plant food in soils varies widely, and every user of commercial fertilizers must select his fertilizer according to the conditions of his soil and the requirements of the crop which he wishes to raise. We are often asked which is the best mixed fertilizer to use. The consumer can better answer this question for himself by a study of his soil conditions and crop requirements. A general statement may be made, however, to the effect that, all conditions being equal, the consumer should select those fertilizers which give the greatest amount of plant food in suitable and available forms for the least money. A study of the tables of analyses should furnish reliable data in making fertilizer selections. The tables show the quality and quantity of the various essential elements of plant food with the possible exception of organic nitrogen. Prescribed methods of analysis do not include a wholly reliable means of determining the availability of organic nitrogen, and in all valuations, in case of the mixed goods, it is assumed that the organic nitrogen is present in the best forms.

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[a] Inspection of Commercial Fertilizers, Mass. Agr. Expt. Sta., Bul. No. 119, December, 1907.

The high-grade fertilizers will, as a general rule, be the most economical ones to buy, and the low-grade fertilizers will, ordinarily, be the most expensive ones. In the manufacture of the best goods only high-grade raw materials and chemicals can be used, as the formula has to be made up of compounds whose united composition will furnish the desired quantity and quality of plant food and whose combined weight must not exceed 2,000 pounds. On the other hand, in the manufacture of very low-grade fertilizers the necessary compounds to supply the percentage of nitrogen, phosphoric acid, and potash which is guaranteed might be supplied in 1,200 to 1,500 pounds of material of good quality, and the remainder, to make up the ton weight, will be a filler of some sort which oftentimes has no fertilizing value whatever. Besides this, the consumer is obliged to pay freight and cartage on low-valued and worthless material. Many low-grade goods contain a high percentage of phosphoric acid. It should be borne in mind that phosphoric acid is the cheapest of the essential elements of plant food and that some of the low-grade mixed goods contain an excess of this material. Cheap or low-grade fertilizers are sometimes made up of crude stock having a comparatively low commercial and agricultural value.

There were 317 brands of fertilizers entered for sale in the State. Of these, there were 249 brands of complete fertilizers, with manufacturers' guarantees of the percentage of phosphoric acid, ammonia (nitrogen), and potash, 155 of them being special brands for special crops. An analysis of these figures for the nitrogenous superphosphates is given herewith.

Composition of nitrogenous superphosphates summarized.

Phosphoric acid.		Ammonia.		Potash.	
Number of brands.	P_2O_5.	Number of brands.	NH_3.	Number of brands.	K_2O.
	Per cent.		*Per cent.*		*Per cent.*
1	11	1	18	2	12
3	10	1	10.25	1	11
22	9	1	8	30	10
2	8.5	1	7.75	1	9.5
105	8	1	7	1	8.75
40	7	1	6.5	1	8.5
2	6.5	9	6	9	8
40	6	2	5.75	2	7.5
15	5	6	5.5	29	7
1	4.5	16	5	2	6.5
13	4	3	4.75	26	6
1	3.5	7	4.5	2	5.5
2	3	7	4.25	22	5
1	2.9	45	4	2	4.75
1	.75	9	3.5	3	4.5
....	....	2	3.25	24	4
....	....	43	3	1	3.75
....	....	30	2.5	1	3.5
....	....	1	2.25	24	3
....	....	32	2	5	2.5
....	....	1	1.75	2	2.25
....	....	9	1.5	46	2
....	....	7	1.25	8	1.5
....	....	14	1	4	1
....	....	....	....	1	.25

Composition of nitrogeneous superphosphates.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	11	3	10	3	8	2.5	6
2	10	4	7	1	8	2.5	5
1	10	3	2.5	11	8	2.5	3
1	9	4.25	2	7	8	2.5	1.5
2	9	3.5	4.75	2	8	2	10
1	9	3.5	4.5	1	8	2	5
1	9	3	2.5	1	8	2	4
9	9	3	2	5	8	2	3
1	9	2.5	2.25	5	8	2	2
1	9	2.5	5	1	8	1.75	2
1	9	2.5	3	2	8	1.5	10
1	9	2.25	2.25	3	8	1.5	2
2	9	2	2	1	8	1.25	10
1	9	2	4	1	8	1.25	3.5
1	9	1.5	2	4	8	1.25	2
1	8.5	1.5	2.5	1	8	1	5
1	8.5	1	1.5	3	8	1	4
1	8	6.5	4	1	8	1	3
1	8	6	8	2	8	1	2
1	8	5.5	8	1	7	8	7.5
1	8	5.5	5	1	7	7	8
1	8	5	10	1	7	6	10
1	8	5	7	1	7	6	5
1	8	4.5	6	1	7	5.5	12
2	8	4.25	7	4	7	5	7
1	8	4.25	5	3	7	5	6
13	8	4	7	2	7	5	5
1	8	4	6	1	7	4.5	10
2	8	4	5	1	7	4.5	8.5
2	8	4	4	2	7	4.25	10
1	8	4	3	1	7	4.25	8.75
1	8	3.5	6.5	2	7	4	10
1	8	3.5	6	1	7	4	9.5
1	8	3.5	4	1	7	4	7
1	8	3.5	10	2	7	4	6
1	8	3.5	8	1	7	3	8
1	8	3.25	7	1	7	3	5
5	8	3	6	1	7	3	4
7	8	3	4	2	7	2	6
2	8	3	5	2	7	2	4
1	8	3	3	2	7	2	2
2	7	1.5	2	1	5	6	2.5
1	7	1.25	2	1	5	5.75	7
3	7	1	1	1	5	5.75	2.5
1	6.5	4.75	4.5	1	5	5	5
1	6.5	2.5	12	1	5	4.75	2
1	6	6	11	1	5	4	7
1	6	6	6	1	5	3.5	5
1	6	5	6	1	5	3	3
1	6	5	5	1	5	3	2
1	6	5	4	1	5	2	10
1	6	5	1	2	5	2	2
1	6	4.5	7.5	1	5	1	10
2	6	4.5	7	1	4.5	2	2
7	6	4	10	1	4	10.25	8
5	6	4	6	1	4	7	10
1	6	3.25	10	1	4	6	6
5	6	3	10	1	4	6	2
1	6	3	8	1	4	4.75	5
2	6	3	5	1	4	4	8
1	6	3	4	1	4	4	7
1	6	2.5	4.5	1	4	4	5
2	6	2.5	2	1	4	4	3.75
1	6	2	4	2	4	3	4
1	6	2	3	1	4	2.5	2
3	6	2	2	1	4	1	8
1	6	1	2	1	3.5	4	3
1	5	18	3	2	3	5.5	5.5
1	5	6	5	1	2.9	7.75	6.5
....	....	....	....	1	.75	5.5	.25

Composition of special brands for tobacco.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	9	2	4	1	7	6	10
1	9	3	2.5	1	7	5.5	12
1	8	2	4	1	7	5	6
2	8	2.5	3	1	7	4.25	8.75
1	8	2.5	6	1	6	6	11
1	8	5	10	1	6	5	1
1	8	4	7.4	1	5	4	7
1	8	4	5.4	1	4	7	10
1	8	4	5	1	4	5	5
1	8	3	3	2	3	5.5	5.5

Composition of special brands for potatoes.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	9	3.5	4.75	1	7	6	5
1	9	2.5	5	1	7	4.5	8.5
1	9	2	2	1	7	4	7
1	8.5	1.5	2.5	2	7	3	6
1	8	4.5	6	1	7	7	8
4	8	4	7	1	7	3	4
1	8	3.5	10	2	7	2	6
1	8	3.5	6.5	2	7	2	4
1	8	3	6	3	6	4	10
1	8	3	5	1	6	4	6
1	8	2.75	5	1	6	3	10
2	8	2.5	6	2	6	3	5
1	8	2.5	5	1	6	2.5	4.5
8	8	2.5	3	1	6	2	4
2	8	2	10	1	4	4	8
1	8	2	3	1	4	1	8
1	8	1.5	10				

Composition of special brands for market-garden crops.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	9	4.25	2	1	7	4.25	10
1	8	5.5	8	1	6.5	5	4.5
8	8	4	7	1	8	6	6
1	8	5	6	1	6	5	6
1	8	4	4	2	6	4.5	7
1	8	3.5	6	2	6	3	10
1	8	3.25	7	1	5	6	5
1	8	3	6	1	5	3.5	5
1	8	2	5	1	5	2	10
2	8	2	2	1	4	4	7
1	8	1	10	1	4	4	5
1	7	5	6	1	4	2.5	2
1	7	5	5	1	2.9	8	6.5

Composition of special brands for corn, grain, and grass.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
2	10	4	7	1	7	4	10
2	9	3	2	1	7	2	2
1	9	2.5	3	2	7	1.5	2
1	8	6	8	1	7	1	1
1	8	5.5	5	1	6.6	2.5	12
1	8	4	3	1	6	5	5
1	8	3.25	8	1	6	4.5	7
1	8	3	6	1	6	3	10
3	8	3	4	1	6	3	8
4	8	2.5	1.5	1	6	2	3
4	8	2	3	1	5	5.5	7
1	8	2	2	2	5	6	2.5
1	8	1.5	2	1	5	5	5
1	7	8	7.5	1	5	5	2
1	7	7	8	1	4	6	2
1	7	5	7	1	4	6	6
1	7	5	6	1	3.9	10.25	8

MAINE.[a]

The following explanatory statement is taken from pages 85–89 of the official bulletin, giving the results of the fertilizer inspection by the Maine station for 1908:

The law regulating the sale of commercial fertilizers in this State calls for two bulletins each year. The first of these contains the analyses of the samples received from the manufacturer, guaranteed to represent, within reasonable limits, the goods to be placed upon the market later. The second bulletin contains the analyses of the samples collected in the open market by a representative of the station.

In the tables which follow the discussion there are given the results of the analyses of the manufacturers' samples of licensed brands. The tables include all the brands which have been licensed to February 10, 1908. Dealers are cautioned against handling brands not given in this list without first writing the station. * * *

To produce profitable crops and at the same time to maintain and even to increase the productive capacity of the soil may rightly be termed "good farming." Many farmers are able to do this, and the knowledge of how to do it has been largely acquired through years of experience, during which the character of the soil, its adaptibility for crops, and the methods of its management and manuring have been made the subjects of careful study, without, however, any definite and accurate knowledge concerning manures and their functions in relation to soils and crops. * * *

Soils vary greatly in their capabilities of supplying food to crops. Different ingredients are deficient in different soils. The way to learn what materials are proper in a given case is by observation and experiment. The rational method for determining what ingredients of plant food a soil fails to furnish in abundance, and how these lacking materials can be most economically supplied, is to put the question to the soil with different fertilizing materials and get the reply in the crops produced. * * *

It is good farming to make the most of the natural resources of the soil and of the manures produced on the farm, and to depend upon artificial fertilizers only to furnish what more is needed. It is not good economy to pay high prices for material which the soil may itself yield, but it is good economy to supply the lacking ones in the cheapest way. The rule in the purchase of costly commercial fertilizers should be to select those that supply, in the best forms and at the lowest cost, the plant food which the crop needs and the soil fails to furnish.

Plants differ widely with respect to their capacities for gathering their food from soil and air; hence the proper fertilizer in a given case depends upon the crop as well as upon the soil. The fertility of the soil would remain practically unchanged if all the ingredients removed in the various farm products were restored to the land. * * *

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[a] Maine Agr. Expt. Sta., Bulletin 153, March, 1908.

The term "form" as applied to a fertilizing constituent has reference to its combination or association with other constituents which may be useful, though not necessarily so. The form of the constitutent, too, has an important bearing upon its availability, and hence upon its usefulness as plant food. Many materials containing the essential elements are practically worthless as sources of plant food because the form is not right; the plants are unable to extract them from their combinations; they are "unavailable." In many of these materials the form may be changed by proper treatment, in which case they become valuable not because the element itself is changed, but because it then exists in such form as readily to feed the plant. * * *

The agricultural value of any fertilizing constituent is measured by the value of the increase of the crop produced by its use, and is, of course, a variable factor, depending upon the availability of the constituent, and the value of the crop produced. The form of the materials used must be carefully considered in the use of manures. Slow-acting materials can not be expected to give profitable returns upon quick-growing crops, nor expensive materials profitable returns when used for crops of relatively low value.

The agricultural value is distinct from what is termed "commercial value," or cost in market. This last is determined by market and trade conditions, as cost of production of the crude materials, methods of manipulation required, etc. Since there is no strict relation between agricultural and commercial or market value, it may happen that an element in its most available form and under ordinary conditions of high agricultural value, costs less in market than the same element in less available forms and of a lower agricultural value. The commercial value has reference to the material as an article of commerce, hence commercial ratings of various fertilizers have reference to their relative cost and are used largely as a means by which the different materials may be compared.

There were 209 brands of fertilizers placed upon the market, of which 186 brands were complete fertilizers containing phosphoric acid, ammonia (nitrogen), and potash, which we will call nitrogenous superphosphates. Of these, 68 brands were designated as special brands for potatoes, and 35 brands for corn, grass, and grain. An analysis of the guaranteed figures shows the following composition of the brands of fertilizers sold in the State of Maine:

Composition of nitrogenous superphosphates summarized.

Phosphoric acid.		Ammonia.		Potash.	
Number of brands.	P_2O_5.	Number of brands.	NH_3.	Number of brands.	K_2O.
	Per cent.		*Per cent.*		*Per cent.*
1	10	1	7	1	12
10	9	1	6	43	10
99	8	9	5	6	8
30	7	1	4.75	23	7
38	6	6	4.50	12	6
4	5	22	4	8	5
3	4	2	3.5	15	4
1	3	51	3	23	3
....	....	29	2.5	2	2.5
....	....	24	2	32	2
....	....	6	1.5	13	1.5
....	....	11	1.25	8	1
....	....	22	1	....	....
....	....	1	.5	....	....

Composition of nitrogenous superphosphates.

Number of brands.	Phosphoric acid.	Ammonia	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	10	4	7	8	7	5	7
1	9	4	6	6	7	4.5	10
5	9	3	2	3	7	3	8
2	9	2	2	1	7	3	5
1	9	2	12	2	7	2	4
1	9	1.5	2	1	7	2	3
2	8	5	7	2	7	1.5	2
1	8	4	10	8	7	1	1
1	8	4	6	1	7.5	1	3
1	8	3.5	4	1	6	5	5
17	8	3	7	17	6	4	10
4	8	3	6	1	6	3.5	10
6	8	3	4	10	6	3	10
4	8	2.5	6	4	6	3	5
14	8	2.5	3	1	6	2	2
11	8	2.5	1.5	1	6	1.5	3
3	8	2	10	1	6	1	6
2	8	2	5	1	6	1	4
1	8	2	4	1	6	1	2
5	8	2	3	1	5	4.75	2
6	8	2	2	1	5	4	10
11	8	1.25	2	1	5	3	10
4	8	1	4	1	5	1	10
1	8	1	3	1	4	6	6
2	8	1	2	1	4	1	8
2	8.5	1.5	2.5	1	4	1	2
2	7	5	10	1	3	7	8
1	7	5	8				

Composition of special brands for potatoes.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	9	2	12	1	7.5	1	3
1	8.5	1.5	2.5	1	7	5	10
1	8	4	10	3	7	4.5	10
6	8	4	7	1	7	3	8
4	8	3	6	1	7	3	5
1	8	3	4	1	7	2.5	8
3	8	2.5	6	2	7	2	4
1	8	2.5	5	12	6	4	10
11	8	2.5	3	5	6	3	10
2	8	2	10	3	6	3	5
1	8	2	4	1	6	1.25	4
1	8	2	3	1	6	1	6
1	8	2	2	1	4	1	8
1	8	1	4				

Composition of special brands for corn, grain, and grass.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	10	4	7	2	8	1.25	2
1	9	3	2	1	7	5	7
1	8.5	1.5	2.5	1	7	1.5	2
1	8.5	1	1.5	3	7	1	1
1	8	5	7	3	6	3	10
3	8	4	7	1	6	3	5
1	8	2.5	6	1	6	1.5	3
5	8	2.5	1.5	1	5	5	2
3	8	2	3	1	4	6	6
4	8	2	2				

NORTH CAROLINA.

There were 1,805 brands of fertilizers registered for sale in North Carolina in the spring season of 1908. The following explanatory matter or advice as to making suitable selections from this great mass of material is taken from the official bulletin giving the results of the inspection,[a] and is probably about all that can be safely and positively stated in a general way with our present knowledge of fertilizers, soil, and crops, but it is in strange contrast with the assurance and knowledge implied in the names and compositions of the brands put out by the different manufacturers:

The analyses presented in this bulletin are of samples collected by the fertilizer inspectors of the department, under the direction of the commissioner of agriculture, during the spring months of 1908. They should receive the careful study of every farmer in the State who uses fertilizers, as by comparing the analyses in the bulletin with the claims made for the fertilizers actually used the farmer can know by or before the time fertilizers are put in the ground whether or not they contain the fertilizing constituents in the amount they were claimed to be present. * * *

Water-soluble ammonia.—The main materials furnishing ammonia in fertilizers are nitrate of soda, sulphate of ammonia, cotton-seed meal, dried blood, tankage, and fish scrap. The first two of these (nitrate of soda and sulphate of ammonia) are easily soluble in water and become well distributed in the soil where plant roots can get at them. They are, especially the nitrate of soda, ready to be taken up by plants, and are therefore quick-acting forms of ammonia. It is mainly the ammonia from nitrate of soda and sulphate of ammonia that will be designated under the heading of water-soluble ammonia.

Organic ammonia.—The ammonia in cotton-seed meal, dried blood, tankage, fish scrap, and so on is included under this heading. These materials are insoluble in water, and before they can feed plants they must decay and have their ammonia changed, by the aid of the bacteria of the soil, to nitrates, similar to nitrate of soda.

They are valuable then as plant food in proportion to their content of ammonia and the rapidity with which they decay in the soil, or rather the rate of decay, will determine the quickness of their action as fertilizers. With short season, quick-growing crops, quickness of action is an important consideration, but with crops occupying the land during the greater portion or all of the growing season it is better to have a fertilizer that will become available more slowly, so as to feed the plant till maturity. Cotton-seed meal and dried blood decompose fairly rapidly, but will last the greater portion, if not all, of the growing season in this State. While cotton seed and tankage will last longer than meal and blood, none of these act so quickly or give out so soon as nitrate of soda and sulphate of ammonia.

Total ammonia is made up of the water-soluble and organic; it is the sum of these two.

The farmer should suit, as far as possible, the kind of ammonia to his different crops, and a study of the forms of ammonia, as given in the tables of analyses, will help him to do this.

The general character of the brands is as follows:

		Brands.
Material valued only for phosphate supplied:		
Acid phosphate, slag, and raw rock		236
Material valued only for nitrogen supplied:		
Nitrate of soda	45	
Sulphate of ammonia	11	
Fish scrap	6	
Dried blood	8	
	—	70
Material valued only for potash supplied:		
Kainit	61	
Muriate of potash	37	
Sulphate of potash	24	
Mixed salts	1	
	—	123

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[a] Analyses of Fertilizers—Spring Season, 1908. The Bulletin of the N. C. Dept. of Agr., vol. 29, No. 4, Apr., 1908.

	Brands
Material valued only for phosphoric acid and nitrogen supplied:	
Bone and tankage	33
Mixed fertilizers:	
Containing nitrogen and potash	5
Containing phosphoric acid and potash	246
Complete fertilizers, containing phosphoric acid, nitrogen, and potash	1,002
	1,805

Of the 1,002 brands of complete fertilizers, 504 are special brands for special crops, as follows: Three brands for fruit; 176 brands for tobacco; 11 brands for peanuts; 38 brands for corn, grain, and grass; 94 brands for cotton; 68 brands for potatoes; 114 brands for truck.

Nearly half of the complete fertilizers, or nearly a third of the whole number of brands offered for sale, purport to be special brands for special crops.

The 246 fertilizers containing only phosphoric acid and potash have the following composition:

Number of brands.	Phosphoric acid.	Potash.
	Per cent.	*Per cent.*
1	21	37
1	13	4
2	13	3
3	12	6
7	12	5
7	12	4
8	12	3
2	12	1
4	11	5
6	11	2
5	11	1
4	10	6
12	10	5
42	10	4
13	10	3
81	10	2
1	9	4
5	8	5
38	8	4
1	8	2
2	7	5

The following special brands for special crops are contained in the phosphoric acid and potash fertilizers:

Peanuts.

Number of brands.	Phosphoric acid.	Potash.
	Per cent.	*Per cent.*
1	11	2
1	10	2
3	8	4
3	7	5

Potatoes.

Number of brands.	Phosphoric acid.	Potash.
	Per cent.	*Per cent.*
1	10	6
1	10	2

Corn, grain, and grass.

Number of brands.	Phosphoric acid.	Potash.
	Per cent.	*Per cent.*
1	12	5
3	12	4
1	10	6
5	10	4
5	10	3
11	10	2
12	8	4

Composition of brands of complete fertilizers summarized.

Phosphoric acid.		Ammonia.		Potash.	
Number of brands.	P_2O_5.	Number of brands.	NH_3.	Number of brands.	K_2O.
	Per cent.		*Per cent.*		*Per cent.*
1	25	1	27.5	17	10
1	23	1	11	2	9
1	17	20	10	17	8
1	17	3	7.5	59	7
2	15	44	7	37	6
2	12	1	6.75	96	5
1	11	15	6	1	4.5
48	10	2	5.5	117	4
26	8.5	76	5	282	3
662	8	2	4.75	2	2.75
81	7	7	4.5	42	2.5
79	6	1	4.25	2	2.25
26	5	91	4	364	2
9	4	11	3.5	7	1.5
3	3	2	3.25	44	1
3	2	246	3		
1	1	42	2.75		
		132	2.5		
		22	2.25		
		329	2		
		41	1		

Composition of brands of complete fertilizers.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	25	4	6	5	9	2	3
1	23	2	2	18	9	2	2
1	17	3.5	3	17	9	2	1
1	16	2	2.5	4	9	1	3
1	15	4.25	3	8	9	1	2
1	15	3	5	1	8.5	3	4
2	12	2	2	1	8.5	3	2.5
1	11	3	4	1	8.5	2.75	2
3	10	4	5	4	8.5	2.5	2.5
2	10	4	4	3	8.5	2.5	1
2	10	3	10	15	8.5	2	2
6	10	3	3	1	8.5	2	1.5
1	10	3	2	1	8	6	6
1	10	2	5	1	8	6	5
1	10	2	4	5	8	5	7
1	10	2	3	7	8	5	5
15	10	2	2	1	8	5	3
1	10	1	5	1	8	5	2
5	10	1	3	1	8	4.75	4
9	10	1	1	1	8	4.75	2.75
1	9	27.5	2	4	8	4.5	7
1	9	6.75	2	1	8	4.5	4
1	9	5	7	2	8	4	7
1	9	5	3	4	8	4	6
1	9	4	7	3	8	4	5
1	9	4	5	40	8	4	4
1	9	4	2.5	6	8	4	3
1	9	3.5	9	1	8	4	2.5
3	9	3.5	5	1	8	4	2
2	9	3	6	1	8	3.5	7.5
1	9	3	5	2	8	3.5	5
1	9	3	4	1	8	3.5	4
13	9	3	3	1	8	3.5	3
4	9	3	2	1	8	3.25	2
1	9	2.25	1	6	8	3	10
22	9	2.75	2	1	8	3	6
5	9	2.5	5	7	8	3	5
4	9	2.5	3	15	8	3	4
6	9	2.5	2	146	8	3	3
4	9	2.5	1	8	8	3	2.5
9	9	2.25	4	11	8	3	2
1	9	2.25	3	1	8	2.75	10
8	9	2.25	1	2	1	2.75	4
1	9	2	4	1	8	2.75	3
9	8	2.75	2.5	1	6	10	2.5
6	8	2.75	2	2	6	10	2
2	8	2.5	6	1	6	7	7
1	8	2.5	5	3	6	7	6
3	8	2.5	4	20	6	7	5
55	8	2.5	3	1	6	6	8
5	8	2.5	2.5	2	6	6	7
33	8	2.5	2	5	6	6	6
5	8	2.5	1.5	1	6	5.5	10
1	8	2.5	1	15	6	5	7
1	8	2.25	2.5	2	6	5	6
2	8	2.25	2.25	3	5	5	5
3	8	2	10	1	6	4.5	4
3	8	2	6	1	6	4	8
5	8	2	5	6	6	4	4
8	8	2	4	1	6	3	6
11	8	2	3	5	6	3	3
210	8	2	2	1	6	3	2.5
1	8	2	1	1	6	2.5	3
9	8	1	4	2	6	2	6
5	8	1	3	1	6	2	5
1	7	8	5	1	6	2	4.5
1	7	7.5	10	5	5	10	3
16	7	7	7	7	5	10	2.5
1	7	7	5	2	5	10	2
1	7	7	4	1	5	8	3
1	7	6	6	2	5	7	5
2	7	6	5	1	5	6	9
10	7	5	8	1	5	6	7
8	7	5	7	2	5	5	5
1	7	5	6	1	5	4	6
18	7	5	5	1	5	3	6
1	7	5	4	1	5	2	10
1	7	4.5	6	1	5	2	6
1	7	4	8	1	5	2	5

Composition of brands of complete fertilizers—Continued.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	7	4	7	1	4	7.5	2.5
1	7	4	5	1	4	4	8
5	7	4	4	3	4	4	6
1	7	3.5	7	2	4	4	4
1	7	3.25	2.75	1	4	3	6
1	7	3	10	1	4	3	5
1	7	3	7	2	3	10	4
1	7	3	5	1	3	8.5	2
1	7	3	4	1	2	11	4
2	7	3	3	1	2	10	5
1	7	3	2	1	2	7.5	1.5
1	7	2	5	1	1	8	10
1	7	2	4				

There are 184 combinations in these 1,092 brands, not counting the differences in material of which they are composed. There are 37 combinations embracing 833 brands, or 76 per cent of the whole number, which have 6 or more brands with identical combinations, as follows:

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
210	8	2	2	9	10	1	1
146	8	3	3	9	9	2.25	4
55	8	2.5	3	9	8	2.75	2.5
40	8	4	4	9	8	1	4
33	8	2.5	2	8	9	2.25	1
22	9	2.75	2	8	9	1	2
20	6	7	5	8	8	3	2.5
18	9	2	2	8	8	2	4
18	7	5	5	8	7	5	7
17	9	2	1	7	8	5	5
16	7	7	7	7	8	3	5
15	10	2	2	7	5	10	2.5
15	8	2	2	6	10	3	3
15	8	3	4	6	9	2.5	2
15	6	5	7	6	8	4	3
13	9	3	3	6	8	3	10
11	8	2	3	6	8	2.75	2
11	8	3	2	6	6	4	
10	7	5	8				

Composition of special brands for tobacco.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
2	9	3.5	5	5	8	3	5
7	9	3	6	6	8	3	4
2	9	2.75	2	40	8	3	3
1	9	2.5	3	2	8	2	3.5
4	9	2.5	2	3	8	3	2
1	9	2.75	4	1	8	2.75	4
4	9	2	2	1	8	2.75	2.5
1	8.5	3	4	13	8	2.5	2.5
1	8.5	3	2.5	21	8	2.5	3
1	8.5	2.75	2	2	8	2.25	2.5
1	8.5	2.5	2.5	2	8	2	4
1	8.5	2	2	2	8	2	3
1	8	4.75	4	20	8	2	2
1	8	4	7	1	6	3	3
1	8	4	5	1	5	6	9
1	8	4	3	1	5	4	6
1	8	4	2.5	2	4	4	6
9	8	4	4	1	4	3	6
1	8	3.5	5	1	4	3	5
1	8	3	10				

Composition of special brands for cotton.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
2	10	3	3	19	8	3	3
1	10	2	3	2	8	3	2
2	10	2	2	1	8	2.75	2
1	10	1	3	1	8	2.5	3
4	9	3	4	1	8	2.5	2
7	9	2.75	2	1	8	2.5	1.5
1	9	2.5	1	31	8	2	2
4	9	2	1	1	7	3.25	2.75
2	9	1	3	1	7	2	5
2	8.5	2	2	1	6	3	3
1	8	4	6	1	6	3	2.5
5	8	4	4	1	4	4	4
1	8	4	3				

Composition of special brands for potatoes.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	16	2	2.5	1	7	3.5	7
1	8	5	7	1	7	3	10
1	8	4.5	7	1	7	3	7
1	8	4	5	1	6	7	7
2	8	4	4	1	6	7	6
1	8	3	5	7	6	7	5
1	8	3	4	1	6	6	7
5	8	3	3	8	6	5	7
3	8	2	10	1	6	5	5
1	8	2	5	1	6	4	4
1	7	7.5	10	1	6	2	6
4	7	7	7	1	5	7	5
5	7	5	8	1	5	6	7
6	7	5	7	1	5	3	6
3	7	5	5	1	5	2	10
1	7	4	8	1	4	8	8
1	7	4	7				

Composition of special brands for corn, grain, and grass.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	11	3	4	3	9	1	2
1	10.5	2	5	1	8	3	6
1	10	2	4	12	8	2	2
1	10	2	2	1	8	1	3
1	10	1	5	2	6	3	3
4	10	1	3	2	5	10	2
3	10	1	1	1	5	2	5
1	9.5	2	1	1	4	7.5	2.5
1	9	2	1	1	1	8	10

Composition of special brands for truck crops.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
1	25	4	6	1	7	8	5
3	10	4	5	9	7	7	7
1	10	4	4	2	7	6	5
2	10	3	10	5	7	5	8
1	10	2	2	2	7	5	7
1	9	3.5	9	12	7	5	5
1	8	6	6	1	7	5	4
1	8	6	5	1	7	4	5
3	8	5	7	1	7	3	5
5	8	5	5	2	6	10	2
1	8	5	3	1	6	7	6
1	8	4.5	7	11	6	7	5
1	8	4.5	4	2	6	6	6
1	8	4	5	3	6	5	7
7	8	4	4	1	6	5	6
1	8	4	3	1	6	5	5
3	8	3	10	2	6	2.75	8
1	8	3	3	1	6	2.75	4
1	8	3	4	1	6	2	4.5
1	8	2.5	6	5	5	10	3
3	8	2.5	4	4	5	10	2.5
1	8	2.5	3	1	5	8	3
2	8	2	4	1	5	5	5
1	8	2	2.25				

ALABAMA.

The following extracts from the Alabama law and comments on the same are taken from the official bulletin giving the results of the fertilizer inspection for 1908:[a]

"SEC. 6. No complete fertilizer, acid phosphate with potash, acid phosphate with nitrogen, or plain acid phosphate shall be sold in this State which contains less than 14 per cent plant food, namely, available phosphoric acid, nitrogen calculated as ammonia, and potash, either singly or in combination: *Provided*, That no complete fertilizer shall be sold in the State which contains less than 1.65 per cent of nitrogen, equivalent to 2 per cent of ammonia.

"SEC. 10. No person, company, dealer, or agent shall sell, expose, or offer for sale in this State any pulverized leather, raw, steamed, roasted, or in any other form, either as a fertilizer or fertilizer material, without first having made full and explicit statement of the fact and registration with the commissioner of agriculture and industries, and furnishing satisfactory proof that the nitrogen is sufficiently available and valuable for the purpose for which it is sold."

As a result of the enactment of the legislation referred to, the quality of the fertilizers found upon the market during the present season is considerably higher than heretofore, though the increase in plant food is chiefly in the phosphoric acid of the fertilizer. It is noted that owing to the change in the minimum limit of plant food some brands supplying the essential fertilizing constituents in entirely different proportions from those heretofore supplied by the brands upon the market have been listed for sale during the present season, and it seems quite probable that good results will follow the elimination of such fertilizers as the 10: 1: 1 goods. Fertilizers of this last-mentioned grade supply only 1 per cent each of potash and ammonia, and where the practice of applying one sack per acre of such a mixture has been adopted, only two pounds each of ammonia and potash are employed per acre of land. Inasmuch as many of our average soils to a depth of 6 inches will weigh about 2,000,000 pounds per acre, it will be seen that the application of such small amounts of ammonia and potash would add to the soil a relatively insignificant amount of plant food, and where these two particular constituents are needed by the soil they are usually needed in much larger proportions.

The situation with respect to the guaranteed composition of the brands on sale in Alabama is simplicity itself as compared with the figures for the four States already mentioned. There are 364 brands of complete fertilizers on sale in the State, of which 341 brands, or 94 per cent, have the following guaranteed composition:

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[a] Annual Report on Fertilizers, Aug. 1, 1908, Dept. of Agr., Montgomery, Ala.

Number of brands.	Phosphoric acid.	Ammonia.	Potash.	Number of brands.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*		*Per cent.*	*Per cent.*	*Per cent.*
251	10	2	2	7	9	3	3
7	10	4	4	17	9	2	3
17	10	3	3	21	8	2	4
5	10	2	3	16	10	2	4

The formula 10: 2: 2 far outnumbers all others, being represented by 251 samples, or 70 per cent of the whole number.

The extreme range in composition in the 341 brands as shown above is 2 per cent phosphoric acid, 2 per cent in ammonia, and 2 per cent in potash. In the remaining 23 brands the phosphoric acid goes up in 3 cases to 12 per cent and down to 6 per cent in 2 cases. Potash goes as low as 1 per cent in 3 brands. These are the extreme limits in composition of the complete fertilizers sold in the State. There are practically no special brands for special crops except cotton. The revenue from the sale of fertilizer tags for the fiscal year 1907-8 is given as $93,748.

GEORGIA.

The Georgia department of agriculture discusses quite fully the compositions of fertilizers and their relation to crops, and actually gives a number of special formulas for special crops, without, however, claiming to base these upon exact knowledge.[a]

The following extract from the state fertilizer inspection law is interesting in this connection:

"Sec. 4. Be it further enacted that the words 'high grade' shall not appear upon any bag or other package of any complete fertilizer, which complete fertilizer contains by its guaranteed analysis less than 10 per cent available phosphoric acid, 1.65 per cent nitrogen (equivalent to 2 per cent of ammonia), and 2 per cent of potash, or a grade or analysis of equal total commercial value; that the word 'standard' shall not appear upon any bag or other package of any complete fertilizer which contains, by its guaranteed analysis, less than 8 per cent available phosphoric acid, 1.65 per cent nitrogen (equivalent to 2 per cent ammonia), and 2 per cent potash, or a grade or analysis of equal commercial value; that the words 'high grade' shall not appear upon any bag or other package of any acid phosphate with potash which shall contain by its guaranteed analysis less than 13 per cent available phosphoric acid, and 1 per cent potash, or a grade or analysis of equal total commercial value; that the word 'standard' shall not appear upon any bag or other package of any acid phosphate with potash which shall contain, by its guaranteed analysis, less than 11 per cent available phosphoric acid and 1 per cent potash, or a grade or analysis of equal total commercial value; that the words 'high grade' shall not appear upon any bag or other package of any plain acid phosphate which shall contain by its guaranteed analysis less than 14 per cent available phosphoric acid; and lastly, that the word 'standard' shall not appear upon any bag or other package of any plain acid phosphate which shall contain, by its guaranteed analysis, less than 12 per cent available phosphoric acid. It is hereby provided that no complete fertilizer, acid phosphate with potash, acid phosphate with nitrogen, or plain acid phosphate shall be offered for sale in this State which contains less than 12 per cent of total plant food, namely, available phosphoric acid, nitrogen when calculated as ammonia, and potash, either singly or in combination: *Provided*, That in mixed fertilizers there shall not be claimed less than 1 per cent potash and 0.82 per cent nitrogen, when one or both are present in the same mixture."

The following rulings have been made by the commissioner, based upon the inspection law:

Fourth.—In case of goods containing 10 per cent available phosphoric acid, 0.82 per cent nitrogen, and 1 per cent potash, or such mixture 9 : 1.65 : 1, or

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[a] Commercial Fertilizers and Chemicals, Season 1907-1908, Serial No. 46, Ga. Dept. of Agr.

8 : 0.82 : 3, or other combinations which do not reach a total commercial value equal to that of the standard fertilizer, which is 8 : 1.65 : 2, such mixtures are not to be designated by any grade at all. Such goods may be offered for sale and branded with any name the market desires to give, provided such name does not indicate that they belong to a high or standard grade.

Sixth.—In the case of goods containing less than 1.65 per cent nitrogen they may be branded as "ammoniated" goods, "guano" or "fertilizer," or other words implying that the same is an ammoniated superphosphate, provided they contain not less than 0.82 per cent nitrogen.

Seventh.—A goods containing 10 per cent available phosphoric acid, 0.82 per cent nitrogen and 3 per cent potash, can not be branded high grade, since it has not as high a commercial value as the legal high grade.

Eighth.—No manufacturer has the right to print the word "ammonia" at all on his sacks.

Sixteenth.—It is hereby ordered, in consonance with the spirit of section 8 of the law, that no cyanogen compounds, dried muck or peat, wool waste, tartar pomace, or Mora meal, or other material not recognized by scientific authorities as being available sources of plant food, shall be used in any fertilizer sold in this State. All manufacturers are warned against purchasing unfamiliar fertilizer materials without first inquiring of this department as to their character.

Under the title "Misleading brand names and a little advice on purchasing," the following occurs:

> It shall be borne in mind always that state valuations are relative and approximate only, and are only intended to serve as a guide. It is much to be desired that farmers should study the analyses giving the actual percentages of plant food more, and pay no attention whatever to names and brands.
>
> They should realize, for instance, that in nine cases out of ten brands known as "pure dissolved bone" contain not a particle of bone, but are made simply out of phosphate rock. They are every "whit and grain" as good as if they were made from bone, the available phosphoric acid from rock being just as available and identically the same as the available phosphoric acid from bone. The proof that such brands are not made from bone is that they contain no nitrogen, and if they were made from bone the percentage of nitrogen would be stated, and would be charged for. This is only one instance of the folly of being influenced by names and brands—many might be given.
>
> Remember that a multiplicity of brands is also expensive to the manufacturer, and you have to pay the cost in the long run. Study the market, select a time for purchasing when general trade in fertilizers is dull, club together with some of your neighbors, and then order from a reliable manufacturer, stipulating, if you have a preference, just what materials the goods shall be made from, and especially the guaranteed percentage of nitrogen, phosphoric acid, and potash. Let the maker call it anything he pleases.

The following proportion of plant food element for special crops is recommended by the department, although the caution is given that "every intelligent farmer will study his environment, his soil, and climatic conditions, and then use his best judgment."

Crop.	Phosphoric acid.	Ammonia.	Potash.
	Per cent.	*Per cent.*	*Per cent.*
Cotton	10	6	3
Corn	8	3	5
Wheat	5	6	3
Celery	5	8.5	8
Potatoes	7	7	8
Beets and lettuce	5	7	8
Cabbage, cauliflower, cucumbers, and melons	5	7	5
Spinach	8	6	6
Radish and turnip	7	6	8
Asparagus	7	6	8
Eggplant and tomatoes	6	6	7
Onions	5	6	8
Sweet potatoes	7	3.5	8
Beans and peas	7	3.5	7

Coming now to a consideration of the composition of the brands actually on the market, we find on the whole an astonishingly small variation in percentage composition of mineral plant food elements, although there is no possible way of determining how much variation there is in the material that went into the several brands.

There were 1,822 brands inspected, analyzed, and placed on the market for sale. Of these, 1,260 brands contain two or more plant food elements (phosphoric acid, nitrogen, or potash) in 106 combinations. There are 26 combinations, however, embracing 1,143 brands, or 90 per cent of the total, in which each combination is represented by 6 or more brands. Of the 1,260 brands containing two or more elements, 1,259 contain phosphoric acid, and 1,163 brands, or 92 per cent, contain from 8 to 10 per cent of phosphoric acid, as follows:

Brands.		Percentage of phosphoric acid.
Number.	Percentage.	
563	45	10
180	14	9
420	33	8

There are 77 brands, or 6 per cent, containing from 11 to 16 per cent, and 19 brands, or 2 per cent, containing from 7 to 5 per cent of phosphoric acid.

There are 1,259 brands containing potash, and 1,189 of these brands, or 93 per cent, contain from 1 to 4 per cent of potash, as follows:

Brands.		Percentage of potash.
Number.	Percentage.	
291	23	4
249	20	3
605	47	2
44	8	1

In addition to these, there are 54 brands, or 4 per cent, containing from 5 to 8 per cent of potash.

There are 987 brands containing nitrogen, and of these 947 brands, or 96 per cent, contain from 1 to 4 per cent of ammonia, as follows:

Brands.		Percentage of ammonia.
Number.	Percentage.	
34	3	4
85	9	3
696	70	2
132	14	1

In addition to these, there are 17 brands, or 2 per cent, containing from 5 to 8.9 per cent of ammonia.

There are 855 brands, or 89 per cent, of all the complete fertilizers in which the variation in composition is from 8 to 10 per cent phosphoric acid, 1 to 4 per cent ammonia, and 1 to 4 per cent potash, as follows:

Brands.		Percentage of phosphoric acid.	Percentage of ammonia.	Percentage of potash.
Number.	Percentage.			
255	27	10	3	2
242	26	8	2	2
90	9	9	2	3
44	5	10	3	3
34	4	10	1	3
28	3	10	2	4
23	2	8	1	3
23	2	10	1	1
23	2	9	1	2
18	2	10	4	4
18	2	8	2	4
18	2	9	2	1
14	1	9	3	2
13	1	9	2	2
12	1	8	3	3

Or, to put the matter in another way, there are 510 brands that differ only 2 per cent in the phosphoric acid, as follows:

Number of brands.	Percentage of phosphoric acid.	Percentage of ammonia.	Percentage of potash.
255	10	2	2
13	9	2	2
242	8	2	2

Then, there is in addition 254 brands in which the extreme variation from the above is 1 per cent ammonia and 2 per cent potash, as follows:

Number of brands.	Percentage of phosphoric acid.	Percentage of ammonia.	Percentage of potash.
28	10	2	4
8	10	2	3
34	10	1	3
1	10	1	4
6	10	1	2
1	9	2	4
90	9	2	3
2	9	1	4
6	9	1	3
23	9	1	2
18	8	2	4
8	8	2	3
6	8	1	4
28	8	1	3

It is apparent, therefore, that 764 brands, or 80 per cent, of the complete fertilizers sold in the State of Georgia have an extreme variation in composition—so far as the official records show, and the manufacturers' guaranty claim—of 2 per cent in phosphoric acid, 1 per cent in ammonia, and 2 per cent in potash. Furthermore, they are far below in ammonia and potash content the formulas proposed by the state inspection, as given on a previous page of this report.

The following is a list of the 255 brands having a guaranteed composition of 10 per cent phosphoric acid, 2 per cent ammonia (1.85 nitrogen), and 2 per cent potash:

List of brands having the guaranteed composition 10 : 2 : 2.

Athens High Grade Guano.
A A A A High Grade Guano.
Acid and Meal Mixture.
Acme High Grade.
Adair's Soluble Pacific.
Alligator Ammoniated Bone.
American High Grade Fertilizer.
10 : 2 : 2 Ammoniated Bone.
Ammoniated Dissolved Bone.
Ammoniated Dissolved Bone and Potash.
Anderson's High Grade.
A. N. Hay's Fish Scrap High Grade.
A. & T. Ammoniated Dissolved Bone.
Atlantic High Grade Ammoniated Guano.
B. & B's High Grade.
Baker's High Grade.
Baker High Grade.
Ball Ground High Grade.
Baugh's High Grade Cotton and Truck Guano.
Bear High Grade Beef, Blood and Bone.
"Big Crop."
Birmingham Blood, Bone and Potash.
Birmingham High Grade Fertilizer.
Black Hawk High Grade.
Black Jack High Grade Guano.
Blood and Bone.
Blood and Bone High Grade.
Blood and Bone High Grade Fertilizer.
Blood and Bone High Grade Guano.
Blood, Bone and Potash.
Blood and Tankage Mixture.
Bowker's High Grade Fertilizer.
Boyd's Acme Soluble.
Boyd's Animal Bone Guano.
Brer Fox Fertilizer.
Brer Rabbit Fertilizer.
Buffalo High Grade.
Burke County Fertilizer.
Campton High Grade.
Capitola High Grade Guano.
Carlton's Best.
Carter's Boll Maker.
C. F. Sasser's Choice.
Chattahoochie.
Cherokee Fish High Grade.
Cherokee High Grade.
Cherokee High Grade.
Chickamauga Fish Scrap Guano.
Chickamauga High Grade Fertilizer.
Chickamauga Peanut Food.
Climax.
C. O. and F. Co.'s High Grade.
Heard County High Grade.
Henry County High Grade Guano.
"High Grade."
"High Grade."
"High Grade."
High Grade Guano.
High Grade Fertilizer.
High Grade Fertilizer.
High Grade Guano.
High Grade Guano.
Hill Billy.
High Grade Ashepoo Fertilizer.
High Grade Bradley Soluble Guano.
High Grade Meal Mixture.
High Grade Victor Guano.
H. and H.'s High Grade C. S. M. Guano.
Hodge Home Mixture No. 3.
Holbrook Cotton Special.
Home Mixture No. 3.
Home Mixture No. 3.
Home Mixture No. 3.
Home Mixture No. 3.
Home Mixture No. 3.
Home Mixture No. 3.
Home Mixture No. 3.
Hoschton Pride and Big Indian Cotton Grower.
H. P. and B.'s Cotton Hustler.
Humber's Compound.
Independent High Grade.
Jackson County Favorite Cotton Producer.
Jacksonville High Grade Fertilizer.
Jasper High Grade.
Jefferson High Grade Complete Fertilizer.
Jefferson Meal, Acid, and Potash Mixture.
Jenkin's Special Blood Guano.
Jewell's High Grade Guano.
J. J. and B. L. Bond and Company's High Grade.
Jones Merc Co. High Grade.
Kirk's High Grade Fish Guano.
Knight's Special.
Langford's Best.
Legal Tender High Grade.
Lewis' High Grade
Lion High Grade Guano.
Lion Power Guano.
Lowry's High Grade Guano.
McCarty High Grade Corn Grower.
McCarty High Grade Cotton Grower.
McClure's High Grade Special.
McDonald and Weaver Acid and Meal
McDuffie's High Grade Guano.
Mansfield Blood and Meal Formula.
Marriman's Cotton Boll.
10:2:2 Cotton Seed Meal Mixture.
Columbia High Grade Cotton Grower.
Coweta Fish Guano.
Coweta High Grade Fertilizer.
Compound Guano.

Cooper's High Grade.
Cooper's High Grade Guano.
Cotton Grower.
Cotton Meal Special.
Cotton Success.
Cotton Tail.
C. P. Lively Son's High Grade.
10:2:2 C. S. M. Mixture.
Davis High Grade Guano.
Daybreak Fertilizer.
Delaware River High Grade Fish Guano.
Eagle High Grade Guano.
E. B. Clark's Cotton Grower.
Empire High Grade Ammoniated Dissolved Bone.
Empire State Blood and Bone.
Etowah High Grade.
Eureka Ammoniated Bone.
Eutaw High Grade Golden Fertilizer.
Farm Bell High Grade.
Farmers Choice.
Farmers Choice.
Farmers Friend.
Farmers High Grade.
Farmers Soluble High Grade.
Farmers Special Number 4.
Farmers Success.
Fayette Company High Grade.
Felton's Favorite.
Fish Compound.
Flannery's Staple Upland Cotton Grower.
Fowler Brother's High Grade Guano.
Fox Favorite.
Ft. Valley No Filler.
Furman's Fish Guano.
Furman's High Grade Fertilizer.
Georgia High Grade.
Georgia High Grade.
Georgia Keystone.
Georgia Test High Grade.
Gibb's Special Cotton Guano.
Gilt Edge High Grade Guano.
Gossett's Blood, Bone, and Meal.
Governor Guano.
Green County Oil Company's High Grade.
Green and Shadburn High Grade.
44 High Grade Guano.
Hammock's High Grade Formula.
Hampton High Grade Guano.
Mastodon Ammoniated Soluble Phosphate.
Maxwell's Favorite.
Mississippi Sawyer.
Monarch Guano.
Moore's Special Pride.
Mortgage Killer.
Mortgage Lifter.
Navassa High Grade Fertilizer.
Neely's Burke County Fertilizer.
Newton County High Grade Guano.
North Georgia Pride.
N. and N's High Grade Ammoniated Guano.
Ober's Special Ammoniated Dissolved Bone.
Oil Mill High Grade Fertilizer.
Old Domian High Grade Guano.
Old Time Fish Scrap Guano.
Oliver's Acid, Meal, and Potash.
Oostanaula High Grade Blood and Bone.
Orange High Grade.
Our Union Ideal.
Owen's High Grade.
Ox Grade Ammoniated Bone.
Ox High Grade Fish.
Patapsca Guano.
Paulding County High Grade.
Paullins' Blood and Bone.
Pelican Guano.
Planter's High Grade.
Planter's High Grade Fertilizer.
Planter's Pride.
Planter's XXXX High Grade Blood, Bone, and C. S. M.
Plow Share Brand Guano.
P. N. P's Complete High Grade Guano.
Pride of Fayette.
Pride of Morgan.
Read's Full Boll.
Read's High Grade Ammoniated Dissolved Bone.
Read's Special Compound C. S. Meal.
Red Cross High Grade Guano.
Red Elk High Grade No. 2.
Redwine's Special.
Rex High Grade.
Romulus High Grade Guano.
Royal High Grade Guano.
Royal Seal Guano.
Royster's High Grade Soluble Guano.
Royston High Grade.
Salmon's High Grade.
Sam Bowers' Acid, Meal and Potash Mixture.
Sam Bowers' High Grade.
Savannah Oil Mill High Grade Fertilizer.
Scott's Gossypium Phosphate.
Seabird High Grade Guano.
Senora High Grade.
Shirley's High Grade.
Smith's High Grade Blood and Bone.
Southern High Grade Fertilizer.
Special Mixture.
S. P. Thompson's High Grade Guano.
S. S. Grant High Grade Cotton Pusher.
S. S. Old Peruvian.
Stafford's Blood and Meal.
Stafford's High Grade Guano.
Strickland's High Grade.
Superior Meal Mixture.
Swift's Eagle High Grade Guano.
The Troup Company's Blood and Bone.
The Troup Company's Ocean Fish Scrap.
Three States High Grade Soluble Guano.
Tonawanda Guano.

Tuscarora Big Crop Fertilizer.
Uncle Joe High Grade.
Uncle Remus' High Grade Guano.
Uncle Sam High Grade Ammoniated Guano.
Uruguay Ammoniated Bone.
Union Ideal Guano.
Upson County High Grade.
U. S. Meal Mixture.
V. C. Chesapeake Fish Guano.
V. C. High Grade Fish Guano.
V. C. Special High Grade Meal Fertilizer.
Vidalia Gold Medal Fertilizer.
Walton High Grade.
Warrior High Grade Complete Fertilizer.
W. A. Shore's High Grade.
W. D. Hawkins' High Grade Guano.
W. and H's Golden Union.
Wilson's Cotton Grower.
Winder High Grade Guano.
W. O. C., a pure Blood Guano.
Woods High Grade.
W. and T. High Grade Cotton Special.
Yellow Jacket Guano.

OBSERVATIONS ON THE DATA.

While the Georgia state department of agriculture recommends that from 200 to 500 pounds of fertilizer be used per acre, it may be safely said that the amount applied by the great majority of farmers is about 200 pounds per acre. Out of the 764 brands, such an application would add from 16 to 20 pounds phosphoric acid, 2 to 4 pounds ammonia, and 4 to 8 pounds potash to an acre.

If we assume that this fertilizer goes into immediate and complete solution and is distributed in the soil moisture to a depth of 6 inches from the surface, and if we assume further that the weight of an acre of soil 6 inches deep is 2,000,000 pounds and contains on the average 15 per cent of water, the maximum effect on the concentration of the soil moisture, diregarding the effect of the fertilizer on the solubility of the soil minerals and the absorbing power of the soil, will be approximately as follows: Phosphoric acid, 53 to 67 parts per million; ammonia, 7 to 13 parts per million; and potash, 13 to 27 parts per million.

So far as the ammonia and potash are concerned, these concentrations are comparable with the normal concentrations of the soil moisture; for phosphoric acid the figures are considerably higher.

It may be assumed that in a majority of cases when used an application of 200 pounds of commercial fertilizer increases the productivity of the soil. An application of 400 pounds or 600 pounds is undoubtedly more efficient, and successful applications up to 3,000 pounds per acre are employed on tobacco, truck, and other special industries.

What immediately concerns us here, however, is the differences in composition in the brands of fertilizers sold and the relative efficiency of these brands when applied to any particular field or crop. We have seen that of the 987 brands of complete fertilizers sold in Georgia markets, 255 brands, or 27 per cent, have the composition 10 : 2 : 2. Several of the dealers and manufacturers put out 6 or 8 more brands of this same composition. Do they differ and have different effects on the soil, and are they more efficient in connection with different crops? Under the state law and trade conditions they virtually have to be sold for the same price per ton. Officially, and so far as the public have certain knowledge, these 255 brands are all one and the same thing, and yet in all probability most of them differ in some essential character in composition and effectiveness, by reason of the material contained or mode and condition of mixture. We know that the different carries of phosphorus, nitrogen, and potassium have very different effects on soils and crops, and the time has come when it would be an advantage to the farmer, and equally to the manufacturer, to determine more nearly the relative effect of materials on soils and crops rather than to pursue longer the study of the elements—for after all it is the material which counts rather than the elements which go to make up the material. That is to say, it is not the potash but the potash salt. There are nitrogenous bodies and potash salts both extremely toxic to plants, but of the common materials which can be safely used for crops, some are more efficient on some soils and some on others, and more should be known about such matters.

Contrast now with 255 brands of the composition 10 : 2 : 2 the 242 brands of the composition 8 : 2 : 2, making together more than half the brands of complete fertilizers sold in the State. Is there a real difference in effect of these two classes due to the difference of 2 per cent of phosphoric acid? Or put the case more strongly still. Take the extreme limits in composition on the great majority (80 per cent) of fertilizers sold in the State, as given above

This would probably be 10 : 1 : 2 and 8 : 2 : 4, or we might take 10 : 2 : 4 and 8 : 1 : 2. The difference in the actual amount of nitrogen and potash is 100 per cent; and to make the same application double the amount of fertilizer would have to be applied in the one case than in the other. The difference is much less in the case of phosphoric acid, but apart from the question of the actual amount, does the difference in proportion shown by these small quantities have an appreciable effect on the soils and crops? In the above formulæ for example, as extreme cases, we might apply 2 pounds per acre of ammonia with either 4 or 8 pounds of potash, or we might apply 4 pounds of ammonia with either 4 or 8 pounds of potash. Would these proportional and actual differences show in their relative effect on the soil and plant? We have reason to believe from laboratory and greenhouse experiments in growing plants in solutions of pure cultures and in soil extracts that they would, but we do not know enough about it, and it is in this direction that further investigations should be made to bring some order out of the problem of the practical application of fertilizers.

AGRICULTURE AS A NATIONAL ASSET.

By Dr. B. T. Galloway,
Chief of Bureau of Plant Industry, United States Department of Agriculture.

SUMMARY.

The latest available figures show that the land area of the United States is, in round numbers, nearly 2,000,000,000 acres. The area in farms is approximately 850,000,000 acres, or 45 per cent of the total land. Irrigation, drainage, and utilization of arid and semiarid lands will probably make available for future use fully 50 per cent more land, or approximately 400,000,000 acres more.

The total wealth produced from the land in 1907 was, in round numbers, $7,500,000,000. As compared with the year 1899, the increase is 57 per cent. The increase in prices of farm products since 1900 is 37 per cent; the increase in prices of all commodities for the same period is 29 per cent; the increase in the value of farm land from the year 1900 to 1905, inclusive, is $6,131,000,000.

For the past five years the exports of agricultural products aggregated $4,565,000,000, reaching a maximum in 1907, when the value of the exports was $1,055,000,000.

The latest available figures show in the United States 6,000,000 farms. On 50 per cent of these farms production is falling off; on the other 50 per cent production is increasing. The average production of all crops has been increasing for forty years. Ninety per cent of the total increase in yields is brought about by 10 per cent of all the farmers.

Not less than 75 per cent of all the farmers in the country are engaged in some form of exploitive agriculture; that is, 75 per cent of all the farmers are taking from the land more than is being put back. Soil exploitation is an economic necessity in any new region or country and will continue where industrial pursuits other than agriculture are not encouraged, supported, and advanced. An equilibrium of industries means national prosperity. As an economic fundamental, selling must be accompanied by buying.

The wealth per capita of the farmer, the value of his land, his ability to select crops and systems of farm management, his power to supplant hand labor by machinery, and his ability to continually and profitably grow crops and at the same time build up and maintain the fertility of the soil are all directly dependent upon the mutual relation of agriculture to other industries. A constructive policy, therefore, for all industries means a constructive policy for agriculture.

The annual wastes from the farm aggregate an amount equal to the annual products, viz, $7,500,000,000. Wastage of soil fertility through erosion, the losses caused by insects, diseases, and other enemies, the losses through misdirected labor, lack of proper capitalization, lack of cooperation and organization in the selling of things produced and the buying of things used on the farm, lack of adaptation to environment or inability to shift crops and practices to changing economic conditions, and lack of knowledge and experience in handling, storing, and transporting corps, are some of the direct and contributing causes of the wastes in question. These wastes are a natural concomitant of our rapidly shifting economic conditions. With the development of other industries and increased population, larger demands for agricultural products and keener competition, the wastes will gradually disappear.

Every type of agriculture, from soil mining by individuals and organized groups of individuals to well-balanced, profitable, and constructive systems, is to be found in this country. The extremes cited are practiced through lack of knowledge and because under existing economic conditions both are found profitable in their respective localities.

Agricultural production in the United States will increase as rapidly as profits justify and the individual farmer shifts his methods and practices in conformity with better knowledge of the economic changes now taking place. The potentialities of production, through improved systems of farm management and increased efficiency of crops as the result of breeding, selection and adaptation, cooperation and organization in buying and selling, utilization of machinery and horsepower, prevention of direct wastes, etc., are sufficient at the present time to double the yields without any increase in acreage.

The problem at hand is not an increase in the number of farmers so much as an increase in the efficiency of the individual farmer and the maintenance of the proper relations between the labor of the farmer and that of other industrial pursuits. If 30 per cent of the labor of the country were engaged in agriculture it would tend toward higher efficiency of the farmer, better prices, better methods, and less direct waste than a larger percentage. A greater efficiency of the farmer and the consequent reclamation and conservation of the natural resources with which he comes in contact may be brought about by proper education, efficient organization, and effective cooperation. Proper education, organization, and cooperation means socializing rather than individualizing the farmer: the broadening of the training of the children of both city and country to the end of creating a just appreciation of all industries.

It means not only the full support of the state in bringing home to the individual farmer all the information that will make the land more productive, but the full support of the state in making the farmer a part of the world movement for social uplift. There are now many forces working to this end and these forces are constantly growing in power and influence. The moment is at hand for a constructive policy having for its object the federation of these forces through a properly equipped and organized federal agency.

AGRICULTURAL PRODUCTION WITH SPECIAL REFERENCE TO CROP RESOURCES.

By **Albert F. Woods**,

Bureau of Plant Industry, United States Department of Agriculture.

In discussing the question of agricultural production from the standpoint of the maintenance of our natural resources, we have to consider, first, those natural factors which are modified, either in the direction of improvement or deterioration, by their use, namely, plants, animals, and the soil, and possibly tools and methods; second, those economic and social conditions which stimulate or suppress the cultural effort and ability of men. This paper will deal briefly with the origin, status, and potentiality of our crop resources. Agriculture has been developed by man in proportion as his needs and desires have exceeded what nature unaided supplied.

PLANTS.

The origin of most of our staple cultivated plants is now believed to be fairly well known[a] and is in most cases of great antiquity. The wild races from which they were selected have in most cases been discovered, aggregating altogether approximately 300 species divided among a considerable number of genera. The list does not include quite a number of American wild fruits and grasses which have come into cultivation within recent years. Practically all of the older cultivated species, however, have been widely scattered over the earth, and have become broken up into a very great number of mutations or variations, some of them sufficiently marked to almost make them new species, if not genera. These selected and cultivated mutations have been handed on from generation to generation, undergoing constant selection and modification as the result of it, until now the number of forms or varieties is very great and represents adjustments to a great variety of climates, soils, cultural methods, uses, and other natural and artificial factors of environment where men have lived.

While the specific relationship of a crop plant is of great importance as indicating its possible range of adaptation, these modifications and adjustments to particular conditions are of far greater agronomic value. These modifications, while not usually considered by botanists as anything more than "place effects" and artificial productions, varieties or strains, are, nevertheless, of the greatest importance to man, as they enable him to live in places often otherwise uninhabitable and furnish material for food and clothing far superior to that obtainable from wild unimproved species. The only object in the life of the wild plant is to grow and reproduce itself, and no energy is lost beyond that necessary to insure this end. When the plant is brought under cultivation, the object is to increase some part of it in quantity or quality, or both, to meet some special need, and this is accomplished within certain limits in proportion to the duration, degree, and intelligence of the selective effort. The most valuable varieties of any crop plant for a locality are those which, as a result of long culture and selection in that locality, have adjusted themselves to the environment without losing their valuable qualities. In the case of cultivated plants, this adjustment is brought about in part by natural selection and partly by artificial selection. In the wild state, through countless generations of variation and natural selection and survival of the fittest, species and their varieties have become adjusted to the conditions under which they had to grow, the principal determining factors of growth being moisture and temperature range or fluctuation of the air and soil, the composition of the soil, disease and insect pests, competition with other species, etc. The power which the plant possesses to adjust itself to these conditions is a matter of the greatest importance, and the range within which a species or variety has the power of adjustment is limited. Crops, therefore, often differ in their relation to each of these factors and their combinations. Each species or variety is adapted to a certain combination and range of these conditions and reaches its best development only where the particular conditions to which the variety is adjusted are naturally or artificially supplied. When any condition varies beyond the limits of this adjustment the crop suffers in some particular correspondingly, and that condition becomes a limiting condition to that particular variety or strain.

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[a] See general table of species, with their origin and the epoch of their earliest cultivation; taken from Origin of Cultivated Plants, by De Candolle, pp. 436-462, inclusive.

These physiological adjustments have not been carefully studied and measured for most of our crop plants and are generally recognized only in their broader relations. No one would attempt the commercial culture of cotton in South Dakota, but many growers buy their cotton seed from southern Texas or Louisiana for culture in northern Texas or Oklahoma, with the result that the long-season adjustment of the southern seed does not fit the shorter season farther north and much of the crop is destroyed by early frosts. Cotton or corn adjusted to the poorer uplands in Texas will go largely to stalk if planted on the richer, moister river bottoms. On the other hand, varieties adjusted to give a balanced growth on the bottom lands fail to give good results on the poorer and drier uplands. In very dry years, however, the upland varieties may do better on the bottom lands than the bottom-land varieties, and in very wet years the bottom-land varieties may succeed better on the uplands than the upland varieties.

As a crop approaches its limits with regard to any factor, the influence of the other factors, which tend to intensify or compensate the reaction to the limiting factor, becomes increasingly important. A variety of corn which can barely mature in the crop season of North Dakota and Minnesota is made more certain if planted on warm, well-drained soil and given very thorough culture. If the soil is heavy and cold or poorly drained, or the crop is planted late or poorly cultivated, it may suffer from early frosts. Farther south with a longer growing season, so far as the temperature limiting condition is concerned, the crop might do better on heavier, moister soil.

In nature related species often live under quite different conditions, certain species being adapted to different ranges and combinations of limiting factors, such as heat, moisture, drought, etc. It is often possible, therefore, by hybridization to produce species having intermediate characters or combining certain characters belonging to one species with certain characters belonging to another species in order to secure a variety adapted to conditions and uses to which neither of the species separately is adapted. When man began to select and cultivate wild species for his use, he, of course, started where he found the species growing wild, and had therefore a mixture of varieties corresponding to the wild forms. His first desire was to obtain a larger yield of fruit, seed, stem, leaves, or root, and he selected those individuals for seed which gave him the most in return for the care he could give them. They thus retained their natural vigor and resistance to limiting factors in their environment along with their specially selected characters. This is well illustrated in the strains of Indian corn as cultivated by the Indians at the time America was discovered and as grown by them still in Mexico and in Central and South America. It is also true of the cottons grown in the same countries. These aboriginal types still retain a wide power of variation, adaptation, and resistance to limiting conditions of their environment, especially where they have been cultivated for long periods exposed to those conditions. According to Cook.[a] many of these Indian tribes of Central America "are peaceable and sedentary, with highly developed agricultural instincts, which attach them closely to the land their fathers cultivated, and there is no reason to suppose that any very different condition existed in earlier times." It is thus evident that these aboriginal cottons and corns have been cultivated for long periods practically under the same conditions of seminatural selection. The characteristics and value of these varieties will be discussed later. The corns and cottons now in cultivation in the United States are selections and adaptations of some of these varieties, originally brought into the country by the Indians. They still retain a wonderful degree of adaptability and variation, which can be controlled in a very large measure by intelligent and long-continued selection.

In the Old World the same phenomenon is exhibited in the case of crops grown by the great masses of poor people, who have been obliged to live for long periods of time under conditions often extremely unfavorable and whose main object in life was to produce enough food to pay tribute with and to feed their families. Generation after generation lived under the same conditions, carefully saving every straw and seed. When some great drought or blight destroyed most of their crop the few remaining plants were not neglected and destroyed, but were carefully saved for seed, as it was often not possible for these poor people to obtain an outside supply. Thus as a result of centuries of such selection and survival of the fittest, we find these poor people possess varieties extremely resistant to the severe limiting conditions under which they were forced by necessity to live. A frequent change of seed, of location, or of economic conditions that would have permitted less careful saving of seed would have lost to the world these valuable products of unconscious natural selection.

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[a] Cotton Culture in Guatemala, by O. F. Cook, Yearbook, U. S. Dept. of Ag. 1904, and Bureau of Plant Industry Bull. No. 88.

As civilization advances and economic conditions improve men often become more careless in the matter of seed selection. If cold or drought or disease causes a failure of the crop, the few straggling plants remaining are destroyed and seed for the next crop is secured in the market, with no knowledge of the conditions under which it was grown. It is, therefore, usually a mixture of seed from different sources, having been grown under conditions sufficiently different so that in a new locality the plants must go through a process of variation and adjustment before they will give satisfactory returns, but as a result of the same careless methods the plants never get a chance to become adjusted to the new conditions. The process of adjustment is mistaken for deterioration or so-called "running out," which in reality is the case where intelligent selection is not practiced. These careless methods have characterized the agriculture of the United States up to very recent times. The greater number of our farmers have given little or no attention to sources of seed or to intelligent seed selection. The rule is to sell the best and plant the culls, which, of course, is selection in the direction of deterioration. As a result of this, complaint is constantly being heard of varieties running out.[a] Many seedsmen have also been guilty of the same careless methods in buying and selling seeds of the great staple forage and cereal crops. Experimenters have also in most cases overlooked these fundamental facts of acclimatization and adjustment in the introduction and testing of new crops, and many a valuable plant resource has been pronounced worthless because it has not been adjusted to the particular conditions under which it was being tested. These adjustments are often physiological and may not change the general appearance or structure of the variety, but are apparent only in its response to the conditions of environment and culture. It is easy, therefore, to substitute such varieties for each other or to overlook them entirely, whereas, with a little careful observation, some of the mutations resulting from the attempt of the plant to adjust itself to its new conditions might prove to be well adapted to the new conditions and produce profitable crops if carefully selected.

As the demands made on the farmer are more exacting and he is rewarded in appreciation and money return for greater care, he rises to the situation. As the agriculture of the country settles down to more definite lines and to a more stable condition, these careless methods will disappear, and in fact have been rapidly disappearing in the past twenty years. This has been most apparent in the selection and improvement of flowers, fruits, and vegetables grown for our best markets. The development of fine varieties, and the care with which they are grown and marketed, has reached a point of the highest excellence in this country, owing to the appreciation of excellence and the high price which our cities are willing to pay for it. In the region of our great markets, like St. Louis, Chicago, Philadelphia, and New York, and the trucking lands tributary to them, the investment in the production of such crops and the annual returns aggregate several hundred million dollars. There have been also, since the earliest settlement of the country, here and there individuals who have taken an interest in the selection and improvement of our staple crops—corn, wheat, cotton, oats, rye, barley, etc.—and many new and improved varieties have been introduced, and have given good results when grown under conditions to which they were adapted. These plant resources are the foundation of our agriculture, and are of more value to us than any other natural asset.

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[a] While failure to properly select is the cause of the real deterioration of varieties, the disappearance of old forms is also due to the development of better varieties, the old forms, therefore, being neglected in favor of the better strains. This is also responsible in part for the idea of the running out of varieties.

It will now be desirable to briefly review our principal plant resources.

INDIAN CORN.

Indian corn is the most widely cultivated and the principal crop plant of the United States. It is a native of tropical America, where a large number of varieties exist, many of which were adapted to conditions (including extremes of moisture, drought, and high altitude) under which the varieties now planted in the United States do not thrive. It is believed that some of these strains will be valuable, either on their own account or for hybridizing purposes with the strains we now have, in order to better adjust them to conditions where corn culture is now uncertain.

Prolonged production of pollen.—One important adaptation of these drought-resisting types of corn is the greater length of time during which pollen is produced. Although the tassels are much smaller than in our United States varieties, the same tassels continue to yield pollen for a period of several weeks, whereas our varieties may supply pollen for only as many days in dry localities or dry seasons. This character furnishes a protection against the loss of a crop through the occurrence of extremely dry, hot weather at the time of flowering, and may have much practical importance in the region to the south and west of our present corn belt, where the growing of our American varieties is prevented by dry climate and hot winds. In fact, the destruction of the pollen by drought and hot winds has been the cause of greatly decreased yields in the center of our corn belt, in Illinois, Iowa, Missouri, Kansas, and Nebraska. If greater drought-resisting qualities could be bred into some of our high-yielding strains of dent corns it would be of immense value, and there is no doubt that this can be accomplished. A study of the fluctuations in yield in the great corn States of the Ohio Valley, upper Mississippi and Missouri valleys, and the Great Plains shows that drought and hot winds are the principal limiting conditions to corn culture, and are often prolific causes of reduced yield. As will be seen by examining the table of annual yields, the great reductions in yield have been in years of severe drought during the growing season, and in those States or parts of States where the drought was most severe the yields have, of course, been lowest. (See article on this subject by the present writer, p. 227.)

In western Nebraska, Kansas, and the Dakotas the annual rainfall is usually not much greater than actually required for the production of average crop yields, and is the principal limiting factor of crop production in that region. The evaporation in the southern part of this area as compared with the northern part is nearly double, so that with the same rainfall the amount of available moisture for a crop will be much less in the southern than in the northern part of the Great Plains. With the same rainfall, therefore, we find the crop yields in the south of this area much less than in the north, owing to the fact that more of the water that falls remains in the soil in the north. The difference between the moisture-holding capacity of soils and the cultural methods adapted to conserve moisture is also brought out clearly in this western region in dry years. Where the soil has been prepared in the fall so as to absorb winter rainfall or melting snow, and cultivation methods have been adopted so as to conserve this water in the soil for the use of crops, good yields are often secured with very small summer rainfall, or, in some cases, even none at all. The different preparation of the soil and cultural methods are often apparent on farms side by side—one farmer raising a good crop on soils where the moisture has been conserved, and his neighbor, who has not followed proper cultural methods, having a total failure. The difference between varieties of plants adapted to growth under dry conditions and those adapted to moist conditions is also here clearly demonstrated.

While the effect of drought on yield is most marked as we approach the limits of available moisture, it is also considerable in the regions of normally heavier rainfall. Under careful experimental conditions at the Illinois Experiment Station, the average yield of 18 varieties was 29.4 bushels in 1887, 83.2 bushels in 1888, and 66 bushels in 1889. Meteorological conditions appear to have been largely, if not solely, the cause of these differences in yield.[a] The average yield for Champaign County, in which the experiment station is located, in 1887 was 20 bushels; in 1888, 42 bushels; in 1889, 35 bushels. The difference between these average yields in the county and at the station may be fairly considered to represent the difference between the best standard culture and the average culture, while the fluctuation between years shows the effect of season, 1887 being a drought year.

Similar fluctuations occurred during the drought of 1894. The average for the northern division of Illinois was 31 bushels, the lowest yield being 15 bushels in Lake County. The average for the central division was 35 bushels, the lowest being 10 bushels in Coles County, and the highest 50 bushels in Calhoun. The average for the southern division was 18 bushels, with a minimum of 3 bushels in Bond County and a maximum of 28 in Madison County.

The soils of northern and central Illinois are much better adapted to absorb and retain moisture than those of the southern part of the State, and the relative evaporation follows the same law as indicated farther west, so that a study of crop yields, even with the same rainfall, in the northern and southern parts of the State shows less effect of drought in the north and greater effect in the south under otherwise the same conditions, the effect, of course, being intensified where the soil is favorable or unfavorable to moisture absorption and retention, and increases in yield also being secured in dry years by those cultural methods which tend to conserve moisture.

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[a] See Abbe, Climate and Crops, p. 334.

In the Southern and Southeastern States, in the cotton belt, where yields are very low as a rule, the moisture factor also plays a considerable rôle. Although the rainfall is much higher than in the northern belt, it evaporates quicker, and the soils as a rule are less retentive of moisture, being in most localities depleted in humus. According to A. J. Henry,[a] "the smallest amount of rainfall that may be expected in the great corn and wheat regions of the central valleys does not vary greatly from 9 to 10 inches (from April 1 to September 30). In the South Atlantic and Gulf States the fall in the year of least rain ranges from a maximum of 20 inches in central and northern Florida to less than 15 inches in the Mississippi Valley and a considerable fringe of country to the westward. The amount of rain that falls in the year of severe drought in the greater part of the Southeastern States is sufficient for the growth and maturity of staple crops, if properly distributed. Success in agricultural pursuits, so far as conditioned upon the rainfall, should therefore be more easily achieved in the Southeastern States than elsewhere, particularly in regions of precarious rainfall." The shallow spring plowing characteristic of the cotton States is not adapted, however, to conserve the water that falls, so that there is seldom a year in which crops do not suffer more or less from drought. The general character of the rainfall of the Southeast is conducive to the development of rather soft growth, evaporating water with considerable rapidity, so that any lack of moisture at the roots is much more evident and injurious than would be the case where the air is drier normally. Experiments conducted through the southern area by the Department of Agriculture and the state experiment stations have shown conclusively that deep plowing, the use of barnyard manures and legumes or other green crops to increase the decaying organic matter and humus of the soil, with shallow summer cultivation, are alone sufficient to raise the average yield of corn in these States to the average of the best corn States.

American strains of corn.—From whatever types in Central America or South America our varieties of corn now in cultivation may have come, we now have in our great central corn belt numerous strains or adaptations of the greatest value. Some of these have become fairly well known, but there are many others which have been grown in certain localities for many years which simply require a little careful selection to bring out their highest yielding capabilities. The corns that we now have fall into six generally recognized groups, as follows: Pop corns, flint corns, dent corns, soft corns, sweet corns, and starchy sweet corns. All of these have their valuable features and uses. The flints and pop corns are generally considered to be cool-region corns, having been grown successfully as far north as Quebec. The flint corns were first introduced and cultivated in the North Atlantic region by the Indians, and has remained to the present time the principal type cultivated in New England. These northern flint strains have thus become adapted to the short seasons of the North. Similar flint varieties, however, were also grown by the Indians in the central and southern localities, in the

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[a] A. J. Henry, Rainfall of the crop season, Yearbook, U. S. Dept. Agr., 1897, p. 617.

See also Relation of precipitation to yields of corn, Yearbook, U. S. Dept. Agr., 1903, pp. 215–224.

Gulf region, and Central and South America, the southern forms having a longer growing season. The flint varieties are lower yielders and less desirable in other characters than the dents.

The dent varieties are generally considered to be longer season sorts and have been cultivated generally south of New York, Minnesota, and the Dakotas. On account of their better quality and higher yielding power, they have been gradually pushed north into Minnesota, Wisconsin, and the Dakotas, and as a result of careful selection high-yielding strains maturing in ninety to one hundred days have been secured. One ninety-day type, bred by the Department of Agriculture in Wisconsin and Minnesota, has yielded as high as 90 to 100 bushels of shelled corn per acre in field tests. A strain developed in Connecticut from Illinois seed of Reid's Yellow Dent has been selected at Hockanum, Conn., since 1905. Very few ears matured in 1905. These were saved and planted in 1906 and practically all the crop matured, yielding 121 bushels of mature shelled corn per acre—more than double the yield of flint corn grown under exactly the same conditions. It is evident, therefore, that high-yielding, quick-maturing dent corns can be developed by careful selection for the colder Northern States.

A similar high-yielding strain of white dent was developed by a farmer near Gainesville, Ga., by planting together four varieties of dent and allowing them to cross. A strain was selected showing evidence of being a cross, which after a few years' selection under the Georgia conditions has proved to be one of the finest dent strains yet developed, yielding from 75 to 100 bushels of shelled corn per acre in field tests, some of the ears weighing over 2 pounds. This is more than double the yield of the unselected dent varieties of the same region grown under the same conditions, and from seven to ten times the average yield of the State.

A number of important selections have been made from time to time which have had an important influence on corn culture, especially in the upper Missisippi and Missouri valleys. Among these may be mentioned the following: Leaming, a deep yellow dent, selected by J. S. Leaming, Wilmington, Ohio, in 1826; Reid's Yellow Dent, selected by J. L. Reid, Delavan, Ill., in 1846; Golden Eagle, a yellow dent, selected by H. B. Perry, Toulon, Ill., in 1871; Boone County White, selected by James Riley, Thornton, Ind., in 1876; Riley's Favorite, a white dent, introduced by James Riley in 1885; Pride of the North, a white dent, introduced by F. A. Warner, Sibley, Ill., 1890. These were principally selections of good individuals of the various types in common cultivation in the region, some of them probably resulting from crosses of different strains. Corn being pollinated by wind-borne pollen, the varieties, of course, often cross, which causes considerable variation and increased vigor. By selecting the best individuals and growing them by themselves for several generations fairly pure types can be developed of much greater producing power than the average. Every strain, however, must be developed under the same conditions in which it is to be grown in order to get the greatest returns from it. This adjustment readily takes place as a result of a few years of intelligent selection.

Investigations and demonstrations carried out in all sections of the United States by the Department of Agriculture and the state experiment stations have shown beyond a doubt that the present average yield of corn per acre could be doubled, with practically no increase in work or expense, by giving careful attention to seed selection and vitality and cultural methods. In our principal corn-growing States corn is planted 3½ feet apart each way, making 3,556 hills per acre. Three stalks to a hill is considered a perfect stand, and with good, vigorous seed it is not difficult to secure on an average three good healthy stalks. If one in three of these stalks produces a small 6-inch or 7-inch ear weighing only a little over 9 ounces, the yield would be 28.8 bushels to the acre. This is the highest average yield for the United States, and occurred in 1905. This, of course, is an exceedingly small amount of grain to secure from three stalks. The average yield for the past forty years has been 25.2 bushels. New Hampshire and Vermont have averaged 35 bushels, fluctuating from 21 bushels in years of drought to 45 bushels in the most favorable seasons, and have shown a gradual increase from 1867 to date. The yields for Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, and Iowa have averaged from 31 to 33 bushels for the entire forty years, fluctuating from about 20 bushels in the driest years to about 40 bushels in the best years. Missouri, Nebraska, Kansas, Kentucky, and Tennessee follow slightly below the States just mentioned, the fluctuations, however, being greater in those States more subject to drought, falling as low as 7 to 10 bushels in Kansas and Nebraska and running as high as 42 to 43 in the same States. The lowest average yields are in the Southern States: Virginia, 19.2 bushels, fluctuating from as low as 13 bushels in dry years to as high as 25 in good years; North Carolina, falling as low as 9 bushels in dry years and running up to 16 bushels in favorable years; South Carolina, falling as low as 6.9 bushels in dry years and running up to 12 bushels in good years; and similar low yields in Georgia, Florida, Alabama, Mississippi, and Louisiana; Texas and Arkansas being a little higher.

The most careful selection of seed has been practiced in Illinois, Indiana, Nebraska, and Kansas, but even in these States the work has not continued long enough to be definitely brought out in general statistical data, but the difference is easily ascertainable in comparing individual growers who use selected seed and good methods with those under the same conditions using ordinary seed and ordinary methods. Good growers who carefully select their seed often obtain a yield of 80 to 100 bushels of shelled corn per acre. It is easy to produce strains that will average three or even four 9-ounce ears per hill of three stalks, but these are very small ears, and strains are very easily developed which produce ears averaging a pound, some of the ears running up to 1½ or 2 pounds. This average is frequently reached and exceeded under identically the same conditions of soil, climate, and culture that with ordinary strains give 40 to 50 bushels or less per acre. With careful attention to seed selection and testing[a] still greater average production for the United States could be reached with little additional cost and greatly increased profits even at present prices.

It is not argued, however, that it is desirable to make any such increase in the total production as this would imply, as the present production is about equal to the demand. An excess over ready demand has a tendency to reduce prices, which is followed by reduced acreage the next season, with a gradual rise in price, followed by increased acreage again. This fluctuation is shown by the tables on yield and prices of corn in the 1907 Yearbook of the Department of Agriculture.[a] However, if one acre could be made to produce as much as two do now, the other acre could be devoted to some other paying crop. Just as much corn would then be produced as at present, with the cost of production per bushel greatly reduced, and the profits, therefore, at present prices greatly increased. It costs little more to plow, harrow, plant, and cultivate an acre for a 100-bushel crop than it does for 40 bushels, and the land tax and rent are the same. These are the heavy fixed charges. Accurate data on the cost of production of farm crops are scarce. The most carefully secured information is to be found in Bulletin 48 of the Bureau of Statistics, U. S. Department of Agriculture, and Bulletins 97 and 109 of the University of Minnesota Agricultural Experiment Station. The following tables are taken from Bulletin 97 of the Minnesota Experiment Station:

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[a] See Farmers' Bulletins Nos. 81, 199, 229, and 253, U. S. Dept. Agr.

Cost of producing corn—ears husked from the standing stalks.

Operation.	Northfield (Rice County).			Marshall (Lyon County).		
	Total acreage (three years).	Total cost.	Cost per acre.	Total acreage (three years).	Total cost.	Cost per acre.
Manuring	602.68	$868.08	$0.576	775.41	$1,140.48	$0.588
Seed value	509.35	108.68	.213	776.71	128.36	.165
Shelling seed	411.07	9.57	.023	467.37	13.06	.028
Plowing	605.89	730.28	1.205	579.78	602.50	1.039
Dragging	791.75	380.37	.480	681.97	305.12	.447
Planting (horse planter)	670.83	150.72	.225	711.08	180.27	.254
Cultivating	776.34	1,256.61	1.619	701.16	934.71	1.333
Weeding				133.04	14.57	.110
Husking on hill	331.32	1,164.77	3.516	169.21	440.09	2.601
Machinery cost			.413			.391
Land rental			3.500			3.000
Total			11.770			9.956

Cost of producing corn—cut, shocked, and shredded.

Operation.	Northfield (Rice County).		
	Total acreage (three years).	Total cost.	Cost per acre.
Manuring	602.68	$868.08	$0.576
Seed value	509.35	108.68	.213
Shelling seed	411.07	9.57	.023
Plowing	605.89	730.28	1.205
Dragging	791.75	380.37	.480
Planting (horse planter)	670.83	150.72	.225
Cultivating	776.34	1,256.61	1.619
Cutting (corn binder)	294.10	195.95	.666
Shocking and tying	270.28	142.24	.526
Twine	248.20	115.84	.467
Picking up ears	139.23	34.60	.249
Shredding	138.18	524.23	3.794
Machinery cost			1.202
Land rental			3.500
Total			14.745

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[a] "Statistics of corn," Yearbook, U. S. Dept. Agr., 1907.

Cost of producing corn—cut, shocked, and hauled in from the field.

Operation.	Marshall (Lyon County).		
	Total acreage (three years).	Total cost.	Cost per acre.
Manuring	775.41	$1,140.48	$0.588
Seed value	776.71	128.36	.165
Shelling seed	467.37	13.06	.028
Plowing	579.78	602.50	1.039
Dragging	681.97	305.12	.447
Planting (horse planter)	711.08	180.27	.254
Cultivating	701.16	934.71	1.333
Cutting (corn binder)	194.00	128.22	.661
Shocking and tying	172.69	58.35	.338
Twine	218.90	80.18	.366
Hauling in			1.640
Machinery cost			1.161
Land rental			3.000
Total			11.020

These figures were based on 40 to 45 bushel yields in 1902, 1903, and 1904. There is not a great deal of difference in the tonnage of stalks between the 40-bushel crop and the 100-bushel crop, the difference being principally in the number and size of the ears. If the stalks are left on the ground, or if they are fed to stock and the manure returned to the ground, the only difference in fertilizer removal will be in the nitrogen, phosphoric acid, and potash in the grain. If the corn is fed and the manure returned to the ground, the loss of fertility would be a negligible quantity. The only other increased cost in caring for a large yield as compared with a small yield is in the case of hand husking and hauling of the product, a method now less followed than formerly, but one which the experiments above referred to indicate is more profitable than the cutting, binding, and shredding. It would not cost as much, however, to husk 100 bushels from 1 acre as from 2 acres, and it would not cost twice as much to husk 100 bushels from 1 acre as to husk 50 bushels from 1 acre, especially if the increased yield was due in part to larger-sized ears. If the harvesting is done by machinery, there would be practically no additional cost in harvesting a 100-bushel crop as compared with a 50-bushel crop. It is evident, therefore, that it would be highly profitable to reduce acreage and increase yield, and that the price could even be considerably reduced and a good profit made. As better and more careful methods of seed selection and culture come into vogue, it is possible that with the higher yields per acre thus secured the price of corn may fall considerably and still a larger profit might result in much the same way as the increase in the efficiency of labor-saving machinery.[a]

All of the investigations conducted by the Department of Agriculture and by the state experiment stations show clearly that where corn is continually cultivated on the same land the yield per acre is greatly reduced. Continued cultivation is especially destructive of humus and reduces the immediately available plant-food elements—nitrogen, phosphoric acid, and potash. The decaying organic matter resulting in the humus sets free in the soil the other elements of plant food from the only slightly soluble soil particles. It is, therefore, exceedingly important to maintain a sufficient amount of decaying organic matter in the soil to insure its best physical condition and the ready supply of plant food through its direct action.[a] As stated above, the first appreciable effect of this constant cropping is the lowering of the humus content of the soil, thus decreasing the nitrogen, and especially decreasing the power of the soil to absorb water and air. This brings about shallower rooting of the corn and makes it less resistant to fluctuations in moisture. The soil dries out more easily and during rains becomes too wet, excluding the air, bakes easily, and is more difficult to keep in tilth. The bacterial life of the soil is thus greatly reduced, resulting in the slower and imperfect decay of organic matter and the formation of nitrates, and a consequent reduction of the solution through bacterial and root action of the other elements of plant food in the soil. The earthworm fauna, which is so necessary to the proper development of humus and soil aeration, is also greatly reduced through the same causes, thus intensifying the unfavorable conditions. As these changes progress the bacterial and animal life changes and species become predominant that are unfavorable to the crops. The nitrifying and ammonifying bacteria become less active or are altogether suppressed, while the denitrifying and nitrite-forming species develop. The latter are well known to be injurious to plant roots. The earthworms die out and soon the life of the soil is gone. It becomes pasty and dead. Fungi often injurious to crops develop rapidly under these conditions, as in the case of the root-rot of Texas, which destroys several million acres of cotton each year. Crops growing in these pasty black adobe soils can not get enough air for the deeper roots, which, thus weakened, are attacked by the fungi present. Deep fall plowing, with a liberal use of barnyard and green manures, partially corrects the trouble and enables the plant to better resist the disease, but most of these soils, after they once get into this condition, also need, in addition to the cultural methods suggested, reinoculating with the natural flora and fauna of good fertile soils where active decay of organic matter by the right bacteria is taking place. These may be partly provided through manure, but it is often necessary to use either soil or cultures of the right forms.[b]

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[a] See 13th Report of Commissioner of Labor, vol. 2. "Hand and machine labor;" also Yearbook, U. S. Dept. Agr., 1897, pp. 600–603.

Constant cropping without rotation, even where there is no serious deterioration of the soil, may also cause the accumulation of insect, animal, and fungous pests of various kinds until it becomes impossible to grow the crop at all on such infected areas. The accumulations of nematodes and root insects are about the only injurious forms in the case of corn, but in the case of other crops, as will be discussed later, numerous other disease organisms cause serious trouble, as in the case of the cotton wilts, flax wilt, etc.

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[a] See Bul. 109, Minn. Agr. Exp. Sta.; Bul. 123, Ill. Agr. Exp Sta.; Farmers' Buls. 81 and 199, U. S. Dept. Agr.; and Soils, by Hilgard.

[b] See The present status of the nitrogen problem, Yearbook, U. S. Dept. Agr., 1906.

WHEAT.

The most careful investigations have indicated that wheat probably originated somewhere in the region of the Euphrates in extremely ancient times. From this region it gradually spread in all directions and is occasionally found in some of its various varieties in the earliest prehistoric remains of nearly all European, Asiatic, and North African countries. Its great value as food and the ease with which it can be carried from place to place, the facility with which it adjusts itself to changing conditions, have all resulted in the development of an immense number of varieties and strains. Even in the earliest prehistoric remains representatives of several distinct strains are found, indicating a very ancient culture.

For purposes of classification and description, eight fairly distinct groups, corresponding to eight botanical species, are recognized:

(1) Common bread wheat, *Triticum vulgare.*
(2) Club or square head, *T. compactum.*
(3) Poulard, *T. turgidum.*
(4) Durum, *T. durum.*
(5) Polish wheat, *T. polonicum.*
(6) Spelt, *T. spelta.*
(7) Emmer, *T. dicoccum.*
(8) Einkorn, *T. monococcum.*

While these large groups are generally considered as species, it must be understood that they probably originated from possibly one or two very closely related natural species, and the modifications resulting in the present rather distinct groups have been the result of long-continued culture and selection under different conditions. However, on account of the exceedingly long period of culture involved, the groups have become as well fixed as natural species.

As a food plant, wheat is even more important than Indian corn, and the demand for it is greater than that of any other cultivated crop. Many statistical studies have been made showing the relation between supply and consumption and the possible world production. It is evident that, with the increasing population of the wheat-using world under the conditions of modern life, there is some danger of the production falling below the demands for consumption. This matter has been discussed in great detail by Crookes.[a] In most of these studies, however, several important considerations have not been given due weight. The most important of these is the improvement in yield through the use of varieties carefully selected for high-yielding power for each locality where the crop is to be grown. This is particularly applicable to the wheat culture of the New World and Australia, where wheat is a more recent introduction and where in many cases it has not become fully acclimatized.

The second important factor is in the improvement of cultural methods, which is applicable throughout the world.

In 1899 Crookes[b] wrote: "The present acreage devoted to the world's growth of wheat is about 163,000,000 acres. At the average of 12.7 bushels per acre this gives 2,070,000,000 bushels. But thirty years hence the demand will be 3,260,000,000 bushels, and there will be difficulty in finding the necessary acreage on which to grow the additional amount required. By increasing the present yield per acre from 12.7 to 20 bushels we should, with our present acreage, secure a crop of the requisite amount." It is interesting to note, however, that for 1902 the production for the world reached 3,124,422,000 bushels, the largest crop ever produced. This falls only a little short of Crookes's estimate of the requirements by the year 1930, and the total production of the world has not fallen below this point to date, being 3,189,813,000 in 1903, 3,152,127,000 bushels in 1901, 3,320,959,000 in 1905, 3,435,401,000 in 1906, and 3,108,526,000 in 1907. This increase is due in part to increased acreage and in part, though very slightly, to increased production per acre by the use of better methods. The following table[a] gives Crookes's estimates, based on the assumption that the population unit consumption and steady development would increase during the forty-three years beginning with 1899 as they had increased since 1871 up to the date of his forecast:

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[a] See The Wheat Problem, by Sir William Crookes. 1900.
[b] Loc. cit., p. 40.

Date.	Bread eaters.	Food and seed required per unit (bushels).	Requiring bushels of wheat.	With yields averaging 12.7 bushels, acreage required.
1871	371,000,000	4.15	1,540,000,000	121,000,000
1881	416,000,000	4.38	1,822,000,000	143,000,000
1891	472,600,000	4.50	2,127,000,000	167,000,000
1898	516,500,000	4.50	2,324,000,000	183,000,000
1901	536,100,000	4.50	2,412,000,000	190,000,000
1911	603,700,000	4.50	2,717,000,000	214,000,000
1921	674,000,000	4.50	3,033,000,000	239,000,000
1931	746,100,000	4.50	3,357,000,000	264,000,000
1941	819,200,000	4.50	3,686,000,000	290,000,000

According to these figures the requirement in the year 1941 will be only 3,686,000,000 bushels, necessitating an acreage of 290,000,000 with an average yield of 12.7 bushels per acre, and feeding 819,200,000 bread eaters. Of course, these figures might be considerably modified at the present time, but they are perhaps as accurate forecasts as could be made of future requirements were the estimates to be projected beyond the present date as these were beyond the date on which they were figured.

The difficulty in all these figures is that there are immense areas in various parts of the world that are not considered at all adapted to wheat growth which can be made available when necessity demands. This is well illustrated by the Great Plains area west of the one hundredth meridian. This area, which at the time Crookes's figures were made was not considered available for wheat production, is now yielding over 50,000,000 bushels of one variety alone of the durum group, and improved methods of dry-land agriculture are making it possible to produce the hard winter wheats in the same area, so that it is exceedingly difficult even at the present time to estimate the potential wheat production of a strip of territory 300 miles wide exending from our northern border to the southern. On the basis of figures compiled by John Hyde, of the Bureau of Statistics, Department of Agriculture, included in full in Crookes's discussion of the wheat problem before referred to, the following statements are made:[b]

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[a] Loc. cit., p. 244.

[b] Loc. cit., p. 195 et seq.

That the population of the United States in 1931, exclusive of colonial possessions or dependencies, will be at least 130,000,000 is as certain as any future event can be, but it is not nearly so easy a matter to forecast the agricultural production of that period. * * * What contribution, if any, will our farmers be able to make to the wheat supply of other countries when the time comes that provision has to be made for the varied requirements of a home population more than twice as large as that at the last federal census?

Those requirements will include a wheat crop of 700,000,000 bushels, without a bushel for export; an oat crop of 1,250,000,000 bushels; a maize crop of 3,450,000,000 bushels, and a hay crop of 100,000,000 tons, all for domestic consumption; with cotton and wool, fruits and vegetables, dairy and poultry products, meat, and innumerable minor commodities in corresponding proportions. The area necessary to the production of the three principal cereals alone will be over 15 per cent greater than the enormous total acreage devoted in 18[illegible] to grain, cotton, and hay, while the mere addition of the two last-mentioned products and of the minor cereals will call for an acreage exceeding the total area of improved land in farms at the present time.

But what, it may be asked, is to prevent either (1) any necessary extension of the areas in farms, or (2) the bringing under cultivation of that large residue of unimproved land which amounted at the last federal census to no less than 42.5 per cent of the total farm area?

The great fact that underlies the enormous productive capacity of the United States to-day is, of course, the transfer from government ownership to individual proprietors, within a single generation, of a body of land hundreds of millions of acres in extent, and for the most part of extraordinary fertility. But, amazing as has been the increase in the farm area of the country during the last thirty years, it has not been sufficient even to keep pace with the growth of population. The addition of 128,300,000 acres, or 31.48 per cent, to the area in farms between 1870 and 1880 only increased the area per capita of population from 10.57 to 10.69 acres. By 1890 the area, notwithstanding a further addition of 87,100,000 acres, or 16.25 per cent, amounted to only 9.95 acres per capita, and the census of 1900 will almost certainly find it under 9 acres.[a]

That for general agricultural purposes the public domain is practically exhausted, and that, consequently, there can be no further considerable additions to the farm area of the country is too well-established a fact to be the subject of controversy. Of the entire area undisposed of, 72.7 per cent is in States wholly within the arid region, and all but a small part of the remainder is desert, mountain, or at best suitable only for grazing purposes. In Kansas, out of 1,061,000 acres undisposed of, only 116,000 acres are east of the one hundredth meridian, and these are described as broken and for the most part sandy. In Nebraska, 10,548,000 acres are still open to settlement, but not one acre in seven is in a region of sufficient rainfall for general agricultural purposes, and the best of the land is described by the General Land Office as fit only for grazing. In North Dakota the vacant land amounts to 20,575,000 acres, but on little more than one-tenth of this area could irrigation be dispensed with, even if the land were otherwise adapted to general farming. In Oklahoma, the youngest of the Territories, and the one containing the largest addition to the farm area of the country that has been made within many years, of the 7,007,000 acres of government land still vacant, 3,250,000 acres lie between the ninety-ninth and one hundredth meridians and a like amount, making altogether 93 per cent of the whole, west of the one hundredth.[b] The vacant land in the Pacific States amounts to 91,843,000 acres; but of the 42,500,000 acres in California, 19,000,000 acres are "barren, irreclaimable wastes," 19,875,000 acres "desert and grazing," and 3,628,000 acres "woodland and forest;" the 35,898,000 acres in Oregon include 17,067,000 acres of "desert and grazing," and 18,831,000 acres of "woodland and forest," while the 13,443,000 acres in Washington comprise 3,847,000 acres of "desert and grazing," and 9,596,000 acres of "woodland and forest."

It should not be forgotten in this connection that it is no longer the policy of the American people or of its representatives in Congress to permit the con-

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[a] The census for 1900 shows the per capita acreage to be a little over 11 acres.

[b] As previously stated, a large proportion of this land west of the one hundredth meridian is now believed to be available for dry-land agriculture and is already contributing over 50,000,000 bushels of one variety of wheat alone to the supply of the United States, over 20,000,000 bushels of which have gone into the export trade.

> tinued destruction of the national forests without regard to the needs of the future. It should also be borne in mind that, according to the United States Geological Survey, the entire water supply of the Pacific States available for irrigation is only sufficient for some 23,000,000 additional acres, or about 1 acre in 4 of the unappropriated public lands in those States. In the entire arid region the available water supply, as similarly estimated by the United States Geological Survey, is only sufficient for the irrigation of 71,500,000 additional acres, or 1 acre in 7½ of the area undisposed of. * * *
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> The extent to which the total farm area of the country can be increased by the reclamation of desert lands will therefore be seen to be very small, if not absolutely insignificant; indeed, it is a question whether it will be sufficient even to counterbalance those constant encroachments upon the productive area which arises from the growth of cities, the building of railroads, and the general development of commerce and nonagricultural industry.

Mr. Hyde then goes on to discuss the great body of unimproved farm land. In the census of 1890, which he had under consideration, there were about 115,000,000 acres of unimproved land in the various farms of the different regions of the United States. The distribution of this land is very ununiform and the extent to which it may be made available is found to differ widely. In Illinois and Iowa it is estimated to be between 15 and 20 per cent of the total farm area; in New York, New Jersey, Pennsylvania, Delaware, Ohio, Indiana, Kansas, and Nebraska, between 20 and 30 per cent; in Vermont, Connecticut, Maryland, Michigan, Missouri, North Dakota, and South Dakota, between 30 and 40 per cent; in Massachusetts, Rhode Island, Kentucky, Wisconsin, and Minnesota, between 40 and 50 per cent; and in Maine, New Hampshire, Virginia, and West Virginia, between 50 and 60 per cent.

> Assuming [says Mr. Hyde][a] that the entire region will, under the influence of high prices, have 85 per cent of its total farm area brought under cultivation within the next thirty years, there will be added to the productive area in this region 60,000,000 acres, with state and railroad lands to the possible extent of 20,000,000 acres in addition. This will fall so far short of the requirements of our own population that it is necessary to seek other possible additions to the cultivable area.
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> Not for the purpose of growing wheat, but under the influence of those generally higher prices which any considerable and long-continued increase in the price of wheat would bring about by reducing the acreage in other products, the South might conceivably add to her productive area as much as 30,000,000 acres. Ten million acres might be added on the Pacific coast and 3,000,000 acres in the arid region. This would make the gross addition 123,000,000 acres, against which must be set those continual withdrawals of land from agricultural uses which not even a high degree of agricultural prosperity would entirely prevent. Assuming the annual rate of diversion to be diminished by one-half, the loss during the next thirty years would amount to about 15,000,000 acres, making the net increase 108,000,000 acres.
>
> This will constitute an enormous addition to the productive capacity of the farms of the country, and one, the contemplation of which, aside from the question of consumption, might well appal our much-discouraged farmers. Considered, however, in the light of the requirements of a population of 130,000,000 the figures assume an entirely different aspect. On the basis of our present actual consumption as a people, to the entire exclusion of our export trade, the country will require by the year 1931 the following additional acreage: For wheat, 13,500,000 acres; for maize, 66,000,000 acres; for oats, 23,700,000 acres; for the minor cereals, 10,000,000 acres, and for hay, 40,500,000 acres, a total of 153,700,000 acres, without making any provision for the proportionately increased consumption of vegetables, fruits, and other products. Instead, therefore, of the probably largely increased acreage, bringing down prices, or proving unprofitable to the farmers, there will be a deficiency of at least 50,000,000 acres. Indeed, it will be more than this, since it can not be supposed for a moment that the unimproved lands left to the last are anything like equal in

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[a] The Wheat Problem, p. 219 et seq.

natural fertility to those first selected for cultivation. On the other side of the account, however, we have to place whatever increase in yield per acre may be brought about by improved methods of farming. But whatever agricultural science may be able to do in this direction within the next thirty years, up to the present time it has only succeeded in arresting that decline in the rate of production with which we have been continually threatened. * * *

It must be borne in mind that it is only to a very small extent indeed that scientific methods have as yet been employed in the growing of field crops. It is unquestionably to the laboratory that we shall have to look for relief, except in so far as it may be afforded by the Government's undertaking the construction of storage reservoirs in the arid region that might reclaim not to exceed 71,500,000 acres, less whatever small area might in the meantime have been brought under cultivation in that region through private enterprise. * * *

The cultivation of wheat at the expense of other necessary crops will, however, be held in check by two very powerful influences. The first will arise from the fact that a reduction of the acreage under any product of general use below the actual requirements of the country will instantly—perhaps even prospectively—affect the price of that product, possibly in a proportion even greater than that by which its acreage is diminished, and may even be sufficient to constitute it a competitor with wheat on equal terms for the farmer's favor. The second check will be found in the fact that the American farmer, north, south, east, and west, has at last fully awakened to the safety, stability, and, in the long run, increased profit resulting from a judiciously diversified system of farming. The one-crop system has passed away, never to return, and before wheat can be extensively cultivated at the expense of other products it will not only have to command what would appear to us as an excessively high price, and afford a reasonable assurance of its continuing to do so, but would have to do this without affecting to any considerable extent the price of other products.

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To discuss the extent to which under conceivable conditions the United States may, notwithstanding this somewhat dubious outlook, still continue to contribute to the food supply of other nations, would be little more than speculation. It is sufficient for the writer's present purpose to have called attention to the enormous prospective increase in the requirements of our own population, and to some of the changes in the agricultural situation which such increase will involve.

This discussion of the subject is quite in accord with the general view taken by Mr. Crookes and a number of others who have forecasted the situation, but the difficulty of making reliable estimates of food production and acreage is too apparent to need further discussion. The same is true regarding the acreage and production of foreign countries, some of which, even in the original home of the wheat plant, are producing only about 9 bushels per acre on the average, as indicated in the following table:[a]

Average yield of wheat per acre in—	Bushels
Denmark	41.8
United Kingdom	29.1
New Zealand	25.5
Norway	25.1
Germany	23.2
Belgium	21.5
Holland	21.5
France	19.4
Hungary	18.6
Roumania	18.5
Austria	16.3
Poland	16.2
Canada	15.5
Argentina	13.0
Italy	12.1
United States (mean)	12.0

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[a] The Wheat Problem, p. 244.

Average yield of wheat per acre in—	Bushels.
India	9.2
Russia in Europe	8.6
Algeria	7.5
South Australia	7.0
Australasia	6.8

The average acreage devoted to wheat in the United States from 1866 to 1907 has gradually increased, slightly fluctuating from year to year through various causes, especially the price of wheat, the price of competing crops, etc. At the close of the civil war, in 1866, there were 15,424,496 acres devoted to wheat, with an average yield of 9.9 bushels and an average farm price of a little over $1.52 per bushel, 12,646,941 bushels of this crop being exported. In 1880 the acreage had increased to 37,986,717, with an average yield of 13.1 bushels and a farm price of a little over 95 cents, 186,321,514 bushels being exported. Up to 1901 the average fluctuated a little above and a little below the 37,000,000-acre point, reaching in 1901 49,895,514 acres, with an average yield of 15 bushels and an average farm price of 62.4 cents, with an export of 234,772,516 bushels. In 1902 the acreage dropped off something over 3,000,000 acres, and in 1903 it came back again to 49,464,967 acres, with an average yield of 12.9 bushels and an average farm price of 69.5 cents, and with an export of 120,727,613 bushels. In 1904, 1905, 1906, and 1907 the acreage has been between 44,000,000 and 47,000,000, with an average yield ranging between 12.9 and 15.5 bushels and a farm price ranging between 66 and 92 cents, the high prices running up as high as $1.13 in the year 1904 and $1.06 in 1906. The exports since 1903 have fallen off considerably. In 1903 the export was 120,727,613 bushels and in 1904 it was 44,112,810. This was coincident with the rust epidemic. In 1905 the exports amounted to 97,609,007 bushels; in 1906, 146,700,425 bushels; and for 1907 the figures were 163,043,669.[a] There is no positive evidence, therefore, from the figures available of any falling off in the ability of our farmers to meet the demand for home consumption of wheat and still supply a large amount for export.

I have already referred incidentally to the difficulty of determining the potential wheat-producing power of the land not now in farms, and of the uncultivated area in farms. As a further illustration of the difficulty of determining this, it is simply necessary to point out that most investigators, including Crookes and Hyde, up to ten years ago, figured that the area west of the one hundredth meridian was practically available only for grazing, with the exception of only a small per cent available for irrigation. Probably not more than 5, or at the most 10, per cent of the arable land west of the one hundredth meridian is considered available for irrigation, owing to the scarcity of water. Even this, however, is based upon the present wasteful methods of using water, and is subject to considerable revision when conditions of farming are such as to warrant subirrigation methods, which are now used in many localities with a saving of over 50 per cent of water. The irrigation ditches are now most of them not cemented or properly silted, so that there is a great waste by seepage. The water, furthermore, is exposed to evaporation, by which large quantities are lost. There are many methods that might be practically devised for using water more economically than at present, but, leaving the question of irrigated agriculture aside, the Great Plains area, which has not been considered as a potential feature in wheat production, is a territory over 300 miles wide and 1,000 miles long, and, on a most conservative estimate, contains 50 per cent of land which could be devoted to wheat culture, and, as a result of careful tests made by the Department of Agriculture, state experiment stations, and practical farmers it has been shown that, by the use of drought-resistant varieties of wheat and by the employment of cultural methods which conserve the natural rainfall, at least 96,000,000 acres of this land could be made to produce an average yield of 15 bushels per acre annually under the ordinary methods of culture now practiced by the best farmers of that region.

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[a] Figures of Bureau Statistics, U. S. Dept. Agr.; subject to slight change by Dept. Com. and Lab.

The possibilities of increasing the wheat yield in the present well-established wheat areas have hardly been considered. As will be shown later, a very large number of varieties are now grown, many of them not well adapted to the conditions of soil and climate under which they are cultivated. An average increased yield of 5 bushels to the acre could be secured simply by putting into the hands of the farmers better adapted strains for their particular conditions. This is now rapidly taking place.

A study of the statistics of yield for the different wheat areas of the United States shows a gradual upward tendency for the United States as a whole for ten-year periods. Representing the average yield of the forty years from 1867 to 1906 by 100, the relative average yield per acre in each decade was as follows: 1867–1876, 94; 1877–1886, 98; 1887–1896, 100; 1897–1906, 108. The actual yields for States and periods are shown in the table of ten-year average yields, herewith appended.

According to investigations made by this department and published in Bulletin No. 24 of the Division of Vegetable Physiology and Pathology, "The Basis for the Improvement of American Wheats," 1900, as a foundation for rational wheat improvement, a knowledge is required, first, of the characteristics and needs of different wheat districts, and, second, of the characteristic qualities of the natural groups of wheat. On the basis of conditions of soil and climate and the nature of the varieties adapted to these conditions, the United States may be considered to be divided into eight wheat districts, as follows: (1) Soft wheat district, including mainly the Middle and New England States; (2) the semihard winter wheat district, including Ohio, Indiana, Illinois, Michigan, and a small part of Wisconsin; (3) the southern wheat district, including approximately the Southern States; (4) the hard spring wheat district, covering the northern portion of the States of the plains; (5) the hard winter wheat district, covering the central portion of the States of the plains; (6) the durum wheat district, covering the western portion of the States of the plains; (7) the irrigated wheat district, including approximately the Rocky Mountain and Basin States; and (8) the white wheat district, including the Pacific Coast States.

Certain general needs, such as early maturity, greater yielding power, and better adapted varieties, are common to all these districts and must be kept constantly in mind in connection with all efforts made to improve varieties. Other characteristics and needs are more special and are stated herewith under headings of the different districts:

Soft wheat district:
- (*a*) Present average yield per acre, about 14⅔ bushels.
- (*b*) Chief varieties now grown: Fultz, Fulcaster, Early Genesee Giant, Mediterranean, Early Red Clawson, Longberry, Jones's Winter Fife, Red Wonder, Gold Coin, Bluestem, Dietz, Red Cross.
- (*c*) Needs of the grower: Harder-grained, more glutinous varieties; hardier winter varieties for the most northern portions; early maturity; rust resistance.

Semihard winter wheat district:
- (*a*) Present average yield per acre, about 14 bushels.
- (*b*) Chief varieties now grown: Fultz, Poole, Rudy, Valley, Nigger, Dawson's Golden Chaff, Early Red Clawson.
- (*c*) Needs of the grower: Hardness of grain; rust resistance; hardy winter varieties.

Southern wheat district:
- (*a*) Present average yield per acre, about 9⅔ bushels.
- (*b*) Chief varieties at present grown: Fultz, Fulcaster, Red May, Rice, Everett's High Grade, Boughton, Currell's Prolific, Purple Straw.
- (*c*) Needs of the grower: Rust resistance; early maturity; resistance to late spring frosts; stiffness of straw.

Hard spring wheat district:
- (*a*) Present average yield per acre, about 14 bushels.
- (*b*) Chief varieties at present grown: Scotch Fife, Bluestem, Wellman's Fife, Velvet Chaff Spring.
- (*c*) Needs of the grower: Early maturity; rust resistance, drought resistance; hardy winter varieties.

Hard winter wheat district:
- (*a*) Present average yield per acre, about 14 bushels.
- (*b*) Chief varieties at present grown: Turkey, Fulcaster, Kharkof, Zimmerman, Fultz.
- (*c*) Needs of the grower: Drought resistance; early maturity.

Durum wheat district:
- (*a*) Present average yield per acre, 11¼ bushels.
- (*b*) Chief varieties at present grown: Mediterranean, Nicaragua, Fulcaster, Turkey, Kubanka (in north).
- (*c*) Needs of the grower: Durum varieties for southern district; drought resistance; rust resistance; early maturity.

Irrigated wheat district:
- (*a*) Present average yield per acre, about 21 bushels.
- (*b*) Chief varieties at present grown: Sonora, Taos, Turkey, Little Club, Defiance, Kharkof, Kubanka.
- (*c*) Needs of the grower: Increase of the gluten content; early maturity.

White wheat district:
- (*a*) Present average yield per acre, about 15 bushels.
- (*b*) Chief varieties at present grown: Australian, California Club, Sonora, White Winter, Foise, Palouse Bluestem, Palouse Red Chaff, Oregon Red Chaff, Little Club.
- (*c*) Needs of the grower: Early maturity; nonshattering varieties; hardy winter varieties in the colder portions.

Attention has already been called to the eight principal groups of our cultivated wheats. The special characteristics of these groups of wheats that are of prime importance in the work of wheat breeding are here given:[a]

1. Common bread wheat group:
- (*a*) Excellence of gluten content for bread making.
- (*b*) Excellence of certain varieties for cracker making.
- (*c*) Yielding power of certain sorts.
- (*d*) Rust resistance (in some varieties).
- (*e*) Winter hardiness of certain varieties.
- (*f*) Resistance to drought of certain varieties.
- (*g*) Early maturity (in some varieties).

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[a] Bull. No. 24, Div. Veg. Phys. and Path., U. S. Dept. Agr., 1900, pp. 79-83.

2. Club or square-head group:
    - (a) Great yielding power.
    - (b) Stiffness of straw.
    - (c) Freedom from shattering.
    - (d) Early maturity (in some varieties).
    - (e) Drought resistance (in some varieties).
    - (f) Excellence of certain sorts for making crackers and breakfast foods.
3. Poulard group:
    - (a) Excellence of certain varieties for making macaroni.
    - (b) Resistance to orange leaf-rust.
    - (c) Resistance to drought.
    - (d) Stiffness of straw.
4. Durum group:
    - (a) Excellence of gluten content for making macaroni and other pastes.
    - (b) Resistance to drought.
    - (c) Resistance to orange leaf-rust.
5. Polish wheat group:
    - (a) Quality of gluten content for making macaroni.
    - (b) Resistance to drought.
    - (c) Resistance to orange leaf-rust.
6. Spelt group:
    - Desirable qualities—
        - (a) Ability to hold the grain in the head.
        - (b) Constancy in fertility.
        - (c) Hardiness of certain winter sorts.
    - Undesirable qualities—
        - (d) Brittleness of the head.
        - (e) Rust liability.
7. Emmer group:
    - Desirable qualities—
        - (a) Ability to hold the grain in the head.
        - (b) Drought resistance.
        - (c) Resistance to orange leaf-rust.
    - Undesirable qualities—
        - (d) Brittleness of the head.
        - (e) Adaptability only for spring sowing, as a rule.
8. Einkorn group:
    - Desirable qualities—
        - (a) Ability to hold the grain in the head.
        - (b) Resistance to orange leaf-rust.
        - (c) Hardiness.
        - (d) Resistance to drought.
        - (e) Stiffness of straw.
    - Undesirable quality—
        - (f) Brittleness of the head.

Wheats may also be grouped geographically. On this basis groups of varieties having certain special qualities are located approximately as follows:

- (a) Starchy white wheats: Pacific Coast and Rocky Mountain States, Chile, Turkestan, Australia, and India.
- (b) Amber or reddish grained wheats, also starchy: Eastern States, western and northern Europe, India, Japan, and Australia.
- (c) Excellence of gluten content for making the best bread: Northern and Central States of the Plains, Canada, eastern and southern Russia, Hungary, Roumania, and southern Argentina.
- (d) Resistance to orange leaf rust: Southern Russia, Mediterranean and Black Sea regions, and Australia.
- (e) Excellence of gluten content for making macaroni: Southern Russia, Algeria, and the Mediterranean region in general.
- (f) Stiffness of straw preventing lodging: Pacific Coast States, Japan, Turkestan, Mediterranean region, and Australia.
- (g) Yielding power (at least in proportion to size of head): Pacific Coast States, Chile, and Turkestan.
- (h) Nonshattering varieties: Pacific Coast States, Chile, Turkestan, Germany (spelts), and East Russia (emmers).
- (i) Constancy in fertility: Germany (spelts) and southern Europe.
- (j) Early maturity: Japan, Australia, and India.
- (k) Resistance to drought and heat: East and South Russia, Kirghiz steppes, Turkestan, and southern Mediterranean region.

(*l*) Resistance to drought and cold: East Russia.

Of the many wheat introductions made into this country in the past, the following are among those of the greatest moment, and which have completely revolutionized the wheat industry in places:

(*a*) Mediterranean, introduced first in 1819.
(*b*) Fife wheats, introduced first into Canada and then into the northern States of the Plains.
(*c*) Turkey wheat, first introduced into Kansas about twenty-five years ago from Taurida, in Russia.
(*d*) The California Club, Australian, and Sonora, introduced into the Pacific Coast States.

Field experiments of the department have shown that in the common bread-wheat group there is a very close constant relation between the autumn condition of the young plant on the one hand and winter hardiness and quality of grain on the other.

Wheat is very susceptible to changes of environment, but especially in regard to color, hardiness, and chemical composition of the grain.

In general, regions possessing black prairie soils and characterized by violent climatic extremes, especially extremes of heat and drought, produce wheats that are hardiest, have the hardest grains, and are the best in quantity and quality of gluten content.

Considering all qualities, the best wheats of the world are of Russian origin, coming particularly from eastern and southern Russia, the Kirghiz steppes, and Turkestan. Of Russian varieties so far known, the following are among the best, if not the very best:

Arnautka, Ghirka Spring, Crimean, Mennonite, Yx, Kubanka, Ghirka Winter, Buivola, Kubanka Red Winter, Chernokoloska, Turkey, Russian, Sarui-bug-dai, Beloturka.

The earliest ripening wheats are often dwarfed. The following varieties are among the best of this class:

Yemide, Onigara, Shiro-Yemidashi, Kintama, Kathia, Roseworthy, Early Baart, Early Japanese, Japanese No. 2, Nashi, Allora Spring, Steinwedel, King's Jubilee.

The following varieties are among the best known of the durum and poulard groups:

Arnautka, Kubanka, Beloturka, Chernokoloska, Medeah, Sarui-bug-dai, Cretan, Galland's Hybrid, El Safra, Petanielle noire de Nice, Volo, Missogen, Atalanti, Nicaragua.

Common bread wheats can not be depended upon to resist rust, but the best in this regard are probably the following:

Turkey, Pringle's Defiance, Rieti, Pringle's No. 5, Nashi, Saskatchewan Fife, Theiss, Bellevue Talavera, Arnold's Hybrid, Crimean, Oregon Club, Odessa, Velvet Bluestem, Sonora, Prolifero, Mediterranean, Deitz Longberry, and Mennonite.

Einkorns resist leaf-rust completely, and emmers resist it to a high degree.

Some of the very hardiest winter varieties so far tried in this country are:

Turkey, Yx, Crimean, Ghirka Winter, Bearded Winter.

Club wheats are usually soft-grained and tender sorts, adapted only to mild climates like that of California. Among the best of this group are:

Little Club, California Club, Herisson barbu, Palouse Red Chaff, Chili Club, Sicilian Red Square-head, Herisson sans barbes.

Some of the most popular and valuable wheats of our country have been produced by simple selection, though in some cases the indications are strong that they were originally the result of natural crossing. The best known of such varieties are:

Fultz, Clawson, Gold Coin, Rudy, Wellman's Fife, Currell's Prolific.

Selection plays far the most important part in wheat breeding, and necessitates on the part of the experimenter a thorough knowledge of varieties and their relations to each other and to their environment.

Simple selection of individuals, however, for the improvement of the same variety, can and should be practiced on every farm. Very little extra time or trouble is required, but the gain is great.

Among the most valuable wheats of the United States that have been produced through hybridization are the following:

Fulcaster, Gypsum, Improved Fife, Quartz, Ruby, Jones's Winter Fife, Early Genesee Giant, Early Arcadian, Pringle's Defiance, Pringle's No. 5, Hornblende, Felspar, Blount's No. 10, Diamond Grit, Early Red Clawson, Early White Leader.

For the most complete success in wheat improvement through hybridization it is necessary to practice composite crossing with parents selected from widely different wheat groups.

The wheat plant is so closely self-fertilized in nature that the practice of composite crossing produces some most interesting and remarkable results. There is apparently no end to the variations exhibited by the sporting progeny in such cases, and, accompanied by discriminating selection, the possibilities of wheat improvement in this way are practically unlimited.

Studying along the lines here laid down, the Department of Agriculture and a number of the state experiment stations have made great progress in improving the varieties of wheat cultivated in these various regions. It has been possible to secure acclimatized strains in various parts of the Old World wheat areas where, as the result of centuries of culture under severe limiting conditions, strains and varieties have been gradually developed through natural and artificial selection very resistant to those conditions. Thus we find very cold and drought resistant durums, like the Kubanka and Arnautka, adapted to the cold dry northern area and other strains developed in northern Africa and the Mediterranean region adapted to the hot dry situations of Texas and Oklahoma. The hard winter wheats of the Great Plains and the Mississippi Valley are inferior in cold-resisting power and yielding power to very closely related strains which have been secured in Russia. As a result of careful explorations of European Russia, including the Caucasus and a portion of the Kirghiz Steppes, as well as Hungary, Roumania, and other portions of Europe, a very large number of promising strains of different varieties were secured, which were tested in connection with a large number of strains secured in this country, making altogether about 1,000 varieties.

The Kharkof strain of the so-called Turkey wheat has carried the range of winter wheat culture from southern Nebraska into southern North Dakota, a distance something over 400 miles, and has carried the western range of winter wheat culture beyond the one-hundredth meridian. This strain is also proving valuable in Iowa, Minnesota, Wisconsin, and Illinois. The winter wheats, besides being more certain in yield, average about 5 bushels more than spring wheats.

The rust-resisting qualities of some of the durum wheats have been bred into the Bluestem strains, making them very much more valuable for culture in the northern Mississippi Valley, but these have not yet been distributed by the department.

The great problem in the South is good varieties of wheat, better adapted for growth under the warmer conditions, and which are rust-resistant. While very little has yet been done along this line, it is undoubtedly possible by the introduction of strains adapted to southern conditions and having greater rust resistance to very greatly increase the now very low yield of the Southern States. Several investigators have from time to time pointed out that the highest yield of any strain of a crop is usually produced near the northern limit of its production. This is true so far as any given strain or variety is concerned, but there is no reason why the Southern States should not be the northern limit of production for certain varieties of wheat, the same as northern Canada is the limit for other varieties. This point has been overlooked in much of the discussion upon the potential wheat-producing power of the Southern States. It is the opinion of those who have given this question long and careful study that the average wheat production of the United States as a whole could easily be doubled by the use of better varieties and better cultural methods. How rapidly changes of this kind will take place will depend upon how rapidly information can be diffused among the farmers. If dependence is placed upon the distribution of information through publications, the change will be very slow, but if the information is carried to the people directly, as is being done by the Department of Agriculture in its farm demonstration in the South, it is believed that even a few years will suffice to get the people to use better methods. It will then be simply a question of how rapidly the scientists can improve the strains and get them into condition for distribution and general use.

The first steps must necessarily be those more fundamental features of general farm practice—the diversification of crops, building up of the humus of the soil by the use of barnyard manure and green crops turned under, more attention given to the selection of even ordinary varieties of seed, etc. As soon as the farmer makes the first steps in this direction, he is able to appreciate and make better use of more highly selected strains and more complicated methods.

The breeding work is actively in progress by many of the state stations, as well as the department experts, and it is probable that the progress of the breeder will fully keep pace with the development of the farmer and that the United States can be depended upon, not only to feed its own rapidly increasing population, with the same relative proportion of wheat that they now use, but that it will have a large and ever increasing quantity for export.

So far as the effect of soil conditions on wheat yield is concerned, it has been proved beyond question that, where wheat is grown continuously on the same soil without the addition of organic matter, the productive power of the soil is reduced. It has been shown beyond any question that the continuous growth of cultivated crops is even more destructive of soil humus than the continuous growth of grain crops. The stirring of the soil in the process of cultivation stimulates the action of the nitrifying and ammonifying bacteria, which convert the organic nitrogen of the soil into available form, so that it is either taken out by the crops or is leached away.

The influence of the different systems of farming on the chemical and physical properties of the soil is well illustrated by the following facts secured at the Minnesota Experiment Station, and which are typical of the results secured by practically all other investigators in this field:[a]

Influence of different systems of farming on the chemical and physical properties of soils.

Character of soil.	Weight per cubic foot.	Humus.	Nitrogen.	Phosphoric acid combined with humus.	Water-holding capacity.
	Pounds.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1. Cultivated 35 years; rotation of crops and manure; high state of productiveness	70	3.32	0.30	0.04	48
2. Originally same as 1; continuous grain cropping for 35 years; low state of productiveness	72	1.80	.16	.01	39
3. Cultivated 42 years; systematic rotation and manure; good state of productiveness	70	3.46	.26	.03	59
4. Originally same as 3; cultivated 35 years; no systematic rotation or manure; medium state of productiveness	67	2.45	.21	.03	57

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[a] Humus in Its Relation to Soil Fertility, by Harry Snyder, Yearbook, U. S. Dept. Agr., 1895, p. 141.

Soils Nos. 1 and 2 are from two adjoining farms, and originally had practically the same crop-producing power. No. 1 has received regular and liberal dressings of manure, and has produced wheat, corn, oats, timothy, and clover in rotation. There has been no apparent decline in fertility. No. 2 has been under continuous grain cultivation and has never received any farm manure or other humus-forming materials. During the first few years heavy crops of wheat were raised, but during the past few years the yield has been very low, especially in dry seasons. The land has been reduced in wheat-producing power from 25 to 8 bushels per acre.

The main difference between the two soils at the present time is in the amount of humus and nitrogen and phosphoric acid.

Soils Nos. 3 and 4 are from the same farm. No. 3 has been cropped forty-two years, timothy and clover, wheat, oats, and corn having been raised in rotation. Every five years the land has received 10 tons of stable manure per acre. No. 4 has been cropped only thirty-five years, producing mainly wheat, oats, and corn, with an occasional crop of timothy. It has not been cropped continuously to one crop, neither has it been under a regular system of rotation. The soil which has been cropped forty-two years shows more humus and nitrogen than the one which has been cropped thirty-five years.

The earlier results secured in these experiments in Minnesota have been confirmed by all of the later investigations. In Bulletin No. 109 of the Minnesota Experiment Station, issued in June, 1908, pages 330 to 334, the results are summarized as follows:

1. Continued cropping of soils to grains only, without any system of rotation, or other treatment, is telling severely upon the original stock of half-decomposed animal and vegetable matter and nitrogen. Soils which have produced grain crops exclusively for ten or fifteen years contain less humus and nitrogen than adjoining soils that have never been plowed.

2. Soils which have been cropped until the organic matter and humus have been materially decreased retain less water and dry out more readily than when there is a larger amount of organic matter present in the soil.

3. Soils which are rich in humus contain a larger amount of phosphates associted with them in available forms than soils that are poor in humus.

4. Soils which are rich in humus and organic matter produce a larger amount of carbon dioxide which acts as a solvent upon the soil particles and aids the roots in procuring food.

5. One-half of a sandy knoll, heavily manured with well-rotted manure, contained nearly a quarter more water during a six weeks' drought than the other half that received no manure.

6. The supply of organic matter in the soil must be maintained, because it takes such an important part, indirectly, in keeping up the fertility. A good system of rotation, including sod crops and well-prepared farm manures, will do this, and will avoid the introduction and use of commercial fertilizers which are now costing the farmers of the United States over $80,000,000 annually. It will not do to wait until this question forces itself upon us.

7. A rotation of crops will soon be necessary on account of the peculiar composition of some of the soils and corresponding subsoils, especially those where the surface soils are richer in phosphates and nitrogen while the subsoils are richer in potash and lime. By means of rotation the full benefit of the strong points of both the top soil and the subsoil will be secured.

The decay of the humus and liberation of its nitrogen is only one of many changes that has taken place. Loss of the element nitrogen can not be said to be the only cause of decline in fertility, as field experiments with fertilizers on old grain lands show that nitrogen alone, when added to the soil, fails to entirely restore the fertility. In addition to the decay of the humus and loss of nitrogen, the mineral elements of plant food have undergone changes in combination, the soils have become lighter in color and otherwise modified in physical properties. * * *

Commercial fertilizers should not be used indiscriminately on old soils with a view of securing large yields, and it is not feasible by their use alone to economically restore the fertility to soils that have been impoverished by exclusive cropping to small grains. Commercial fertilizers are of great value when judiciously employed in a rotation and for encouraging the growth of legumes, as clover, so as to add nitrogen to the soil from atmospheric sources. * * * Commercial fertilizers can not take the place of farm manures or crop residues, particularly those from clover and timothy, for permanently improving the soil, but they aid in the production of some crops and often assist a crop, as clover, which in turn is beneficial in adding nitrogen and humus to the soil.

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A rotation of grain crops alone, without the production of clover or a grass crop, was found not to be sufficient to conserve the nitrogen content of the soil, even where farm manures were used. A rotation of crops, in order to be effectual, must contain clover as one of the essential parts.

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The beneficial action of a clover sod, grass crop residues, and farm manures upon the soil is not alone confined to supplying nitrogen and humus-forming materials, but chemical, bacteriological, and physical changes are also promoted in the soil. * * *

The indiscriminate practice of bare summer fallowing has been another cause of loss of the soil's nitrogen and humus. * * * Experiments show that when summer fallowing is practiced five times more nitrogen is rendered soluble and available than is required for the succeeding crop; and the soluble nitrogen that is not utilized as plant food is readily lost. * * *

On most western farms it is more economical at the present time to make the reserve mineral matter available as plant food than to purchase new stores. In many soils there is a large amount which is not in the most available forms, but is capable of being made so by cultivation.

As a general result of the cropping system it was found that any system which provided for the maintenance of a supply of vegetable matter in the soil, either by manuring or by the growing of pasture or meadow crops, has given profitable returns. A standard five-year rotation—first year, corn, receiving 8 tons of manure per acre; second year, wheat; third and fourth years, meadow; fifth year, oats—has given an average gross income per year for the State of Minnesota, based on average farm prices, of $14.08. The cost of production, including $3.50 land rental, is $9.05, leaving the net annual income $5.03 per acre.

The plots which have grown cultivated crops, such as corn, potatoes, and mangels, continuously without manure, have given poorer returns than have the plots which have grown grain continuously without manure.

A four-year rotation—millet, barley, corn, and oats—gave no better returns than did the plot on which wheat was grown continuously.

The yields of wheat in the standard five-year rotations have ranged between 20 and 30 bushels, some seasons and rotations giving as high as 35 bushels, while the average for the State is about 13 bushels.

Emmer.—Before closing the discussion of wheats attention should be called to emmer, which is destined to be an exceedingly important dry-land crop for high altitudes and poor soils. The following is abstracted from Farmers' Bulletin 139:

Emmer is a species of wheat, *Triticum dicoccum*, probably derived in prehistoric times in southeastern Europe from a still simpler species, *T. monococcum*. It is often confused with another similar species, *T. spelta*, and is thus incorrectly called "spelt." The grain is somewhat similar to that of spelt, but is usually harder, more compressed at the sides, and redder. Emmer is a much more hardy plant than spelt in every way. It resists drought and attacks of leaf rust to a great degree. Fall-sown varieties are also quite winter-hardy. It will produce a fair crop under almost any condition of soil and climate, but thrives best in a dry prairie region with hot summers, where it gives excellent yields, 30–60 bushels. The grain is largely cultivated in the upper Volga region of Russia, where the climatic conditions are more severe than in our northern Great Plains region. Excellent varieties are also grown in the North Caucasus, in Germany, Switzerland, France, Italy, Servia, Abyssinia, northern India, China, and Thibet. Only a few varieties, however, have yet been introduced and tested in this country. From the tests thus far made the Russian white-chaff varieties give excellent results in the northern plains district, and the black winter varieties give good results further South. With the introduction and acclimatization of new varieties this grain promises to take an important place in our agriculture, replacing oats and barley under conditions too severe for those crops and being about equal to them as stock food.

OATS.

A statement [a] of the status of oat culture in the United States has been especially prepared by Mr. C. W. Warburton and is submitted herewith.

The improvement and adaptation of varieties and the greatly increased yields resulting from such work are fully as great as in the case of corn and wheat.

Although oats exceed in nutrition value our other cereals, probably less care has been given to their culture than to any other important crop; oats are usually grown also on the poorest land. Their great value as feed, especially for horses, results in their culture even at a loss, so far as their market value is concerned. The acreage devoted to oats doubled from 1879 to 1887 and increased from 1887 to 1900 from 25,920,906 acres to over 27,000,000, with a corresponding increase in yield. In 1907 the acreage was 31,837,000, but on account of rust, smut, insect pests, and unfavorable weather conditions, the yield fluctuated considerably in various years and localities. The loss from smut alone is estimated at not less than 4 per cent of the crop, or on an average of about 34,000,000 bushels. This can be easily prevented at very small cost. Rust is more difficult to control, except through the use of resistant varieties. The loss caused is fully as great as that caused by smut. Selection and adaptation of varieties, with better rotation systems, will greatly increase the yield per acre as soon as there is demand for it. At current prices the acreage will probably remain about as at present, with a tendency to decrease as average yields increase as the result of better systems of rotation. The net profits will at the same time considerably increase.

BARLEY.

Barley is successfuly cultivated under a wider range of climatic and soil conditions than any other cereal, though it reaches its best development in warm, dry climates. Barley belongs to the same tribe as wheat and rye. The chemical composition of the grain, after taking off the hull, is almost identical with wheat. It is one of the oldest of cultivated crops. Down to the sixteenth century it was the chief bread plant of Europe, but since that time it has given way to wheat. Its chief use in America is as food for domestic animals and for malting purposes. In 1850 New York produced about 69.4 per cent of the barley grown in the United States. The North Atlantic division produced 81 per cent. In 1900 the center of production was the northern Missouri Valley, in Iowa and South Dakota. Nine States now produce about 91 per cent of the total yield, viz., California, Minnesota, Wisconsin, Iowa, South Dakota, North Dakota, Washington, New York, and Nebraska,[b] the first four producing three-fourths of the total crop. The world's production of barley for the past five years, 1903 to 1907, has been a little over 1,200,000,000 bushels. The acreage has gradually increased in the United States from 492,532 in 1866 to 1,131,217 in 1867, reaching 2,272,103 in 1882, 3,220,834 in 1889, falling a little below 3,000,000 from 1896 to 1900, then increasing to 4,295,744 in 1901, 5,145,878 in 1904, and 6,448,000 in 1907.

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[a] See statement on Oat Crop of the United States prepared by C. W. Warburton for this report.

[b] See Cereals in America, by Thomas F. Hunt.

The yield per acre has fluctuated between 19.2 and 29 bushels, averaging, from 1867 to 1876, 22.8 bushels; from 1877 to 1886, 22.4 bushels; from 1887 to 1896, 22.7 bushels; and from 1897 to 1906, 25.5 bushels.

The farm value has been gradually declining, but it increased in 1907 to 66.6 cents, the highest since 1881.

Varieties.—There are two well marked types of barley, the six-rowed and the two-rowed, both of very ancient cultivation and possibly representing separate species. An intermediate form (*Hordeum vulgare L.*) is the common four-rowed barley. The two-rowed varieties of the Hanna and Chevalier type appear to be better adapted to the drier Northwest; while the six-rowed varieties, like Oderbrucker and Odessa, do better in the moister regions. North of the forty-third parallel it is necessary to sow in the spring, but south of this line fall sowing is rapidly coming into favor, especially since 1903, when the Department of Agriculture began to demonstrate the superior value of the winter strains, which yield on an average 25 to 30 per cent more than the spring sorts south of the forty-third parallel. The principal reason is that the fall-sown grain ripens before the hot summer weather arrives. Drilled winter barley in Indiana, Illinois, and Ohio has stood the winter better than broadcasted barley, two-thirds of the loss from winter killing being prevented by this method.

Several years ago the Department of Agriculture introduced a considerable number of hull-less and beardless barleys from the high plateaus of the Himalaya Mountains in Asia and distributed them through the Rocky Mountain States. Their success has been phenomenal. Their cultivation has been successfully carried up to nearly 9,000 feet, where they give valuable hay as well as grain. Large quantities are grown under irrigation in the mountain sections of Montana, Wyoming, and Colorado. They have also been found to be well adapted to the semiarid area of the Great Plains, proving to be one of the best dry-land crops. Like wheat, oats, and corn, and, in fact, most other crops, the barleys do best in soils rich in humus and decaying organic matter. They decline rapidly in yield if the humus and organic matter is not maintained, being more sensitive than other cereals in this respect. In the rich tule lands of California a yield of 80 to 90 bushels per acre is often secured, and under favorable conditions nearly as high yields are often secured in the northern Mississippi Valley. Under average conditions, however, 35 to 40 bushels is considered a fair yield. This is from 10 to 15 bushels above the average for the last decade for the principal barley area and from 15 to 20 bushels above the average for the South. As better rotation methods and cultural methods generally come into use the average yield of this crop, like that of all others, gradually increases.

RYE.

The acreage of rye in the United States has fluctuated between one and a half million and two million acres from 1866 down to the present. The average yield per acre declined slightly down to the beginning of the last decade, during which there has been an average increase of 3 bushels per acre (13.6, 13.0, 12.9, 15.7). The farm value has fluctuated considerably, falling as low as 40.9 cents in 1896, ranging between 50 and 60 cents during the last ten years, reaching 68.8 cents in 1904 and 73.1 cents in 1907. The exports fluctuate greatly.

From the standpoint of its grain value, rye is the least profitable of our cereal crops. It is, however, adapted to very light, poor land, and will make a fair crop where other cereals, with the exception of emmer (sometimes erroneously called "spelt"), would fail. Like the other cereals, however, it responds to better soils or to fertilization.

On account of its great hardiness and its ability to grow on poor soils, it is largely used as a green manure crop.

There is a great demand for rye straw for paper and for other purposes, and, except where it is grown for green manure, it is grown principally for the straw. The grain makes a good flour for human food, but in this country it is not much used except for domestic animals and for brewing purposes.

The yield could be greatly increased, if desired, both by the use of better cultural methods and by selection of high-yielding strains.

RICE.

This is a cereal crop especially adapted to wet soils where other cereals will not grow. The genus *Oryza* is tropical, and there are a number of species of the genus growing wild in the Tropics of both hemispheres. A closely related genus, *Zizania*, is widely distributed in semitropical and northern countries. *Z. aquatica* occurs extensively in marshy places throughout North America and northeastern Asia. In North America it was extensively planted in marshes and used by the Indians as food. The southern wild form of the Gulf States, *Z. miliacea*, is used only for hay.

The cultivated rices originated in southern Asia in prehistoric times. There are five principal groups, corresponding possibly to species, indigenous to southern Asia, especially China. Like other cereals, there are a great number of varieties or strains adapted to a great variety of conditions, both upland and aquatic. One hundred and sixty-one varieties are recognized in Ceylon alone, and about 1,400 in China, India, and Japan. Only a few varieties have been introduced into culture in the United States, though about 800 are under test by the Department of Agriculture.

The principal areas in the United States devoted to rice are (1) the delta land and inland marshes of the South Atlantic States, (2) similar land along the Gulf coast and the southern Mississippi River, and (3) the prairie soil of southwestern Louisiana and southeastern Texas. The prairie rice culture is much like that of wheat or oats. The upland rices, however, are not as good in quality or as high yielding as those grown under irrigation, and, while it can be grown on any soil that will produce corn or cotton within the cotton belt, it will not compete with other grains on these soils as a rule. Where irrigation is practicable, as it is in some of the prairie regions of southwestern Louisiana and southeastern Texas, systems of irrigation and culture have been developed by which it is possible to use the same machinery as is used in cultivating wheat, thus greatly lessening the labor cost as compared to culture in swampy areas, which can not be drained sufficiently to permit the use of such machinery. The following table, taken in part from Farmers' Bulletin 110, shows the difference in labor cost for the United States as compared with other countries:

Number of acres one man can farm in rice, with wages, in different countries.[a]

Countries.	Acres.	Farm wages, in gold per year, with board.
Japan	½ to 2½	$10 to $18
China		8 to 12
Philippines		15 to 20
India	3	10 to 20
Siam	3	10 to 20
Egypt	4	15 to 30
Italy	5	40 to 60
Spain	5	40 to 60
United States:		
Carolinas	8	96 to 120
Mississippi Delta	10	120 to 144
Southwestern Louisiana and Texas	80	180 to 216

[a] Farmers' Bul. No. 110, p. 10. U. S. Dept. Agr., 1900.

The following table shows the acreage, production, and value of rice in the United States in 1907, by States:

Acreage, production, and value of rice in the United States in 1907, by States.

State.	Area.	Average yield per acre.	Production.	Average farm price December 1.	Farm value December 1.
	Acres.	*Bushels.*	*Bushels.*	*Cents.*	*Dollars.*
North Carolina	1,000	23.0	23,000	91	21,000
South Carolina	19,100	27.0	516,000	107	552,000
Georgia	2,400	34.0	81,000	105	85,000
Florida	2,300	30.0	69,000	110	76,000
Alabama	1,400	25.0	35,000	95	33,000
Mississippi	1,100	22.0	24,000	90	22,000
Louisiana	310,000	28.0	8,680,000	85	7,378,000
Texas	284,000	32.0	9,088,000	85	7,725,000
Arkansas	6,000	37.0	222,000	85	189,000
United States	627,300	29.9	18,738,000	85.8	16,081,000

The yields have been greatly reduced in the Carolinas by a disease known as "blast." It is believed that varieties resistant to the disease can be developed. The same disease has appeared in the rice areas of Louisiana and Texas, where it is already causing considerable trouble. The introduction by the Department of Agriculture of better milling and better yielding varieties, especially the Kiushu, greatly stimulated the culture of this cereal in the Louisiana and Texas prairies.

According to Knapp, there are about 10,000,000 acres of land in the five States bordering on the Gulf of Mexico well suited to rice cultivation. Only about 3,000,000 acres of this, however, can be irrigated and cultivated by machine methods. As rotation systems will be required in order to control weeds and keep up the humus supply, only about one-half of this would be devoted to rice in any one year. The present acreage devoted to rice, as shown in the table just cited, is 627,300, with an average production of 29.9 bushels, or 18,738,000 bushels. Besides this the United States annually imports over 120,000,000 pounds of rice. The amount has been gradually increasing, being over 200,000,000 pounds in 1906. It is evident, therefore, that the demand for rice is increasing. If the million and a half acres available for rice each year in the South should be put into this crop and the yield should be about the average of 10 barrels (162 pounds) per acre, the product would amount to 2,500,000,000 pounds of cleaned rice, nearly six times the amount of our present consumption. It is evident, therefore, that this food resource has great potential value and can fully keep up with the demand at remunerative prices. As Knapp[a] states in Farmers' Bulletin No. 110:

> The employment of machinery in the rice fields of the Southwest similar to that used in the great wheat fields of California and the Dakotas is revolutionizing the methods of cultivation and greatly reducing the cost. The American rice grower, employing higher-priced labor than any other rice grower of the world, will ultimately be able to market his crop at the least cost and the greatest profit. If, in addition, the same relative improvement can be secured in the rice itself, if varieties which yield from 80 to 90 per cent of head rice in the finished product can be successfully introduced, American rice growers will be able to command the highest prices for their product in the markets of the world. In view of the success in this direction of the Kiushu rice, experimentally introduced by the Department of Agriculture, more than 100 tons of this rice were ordered from Japan by Louisiana planters for the season of 1900.

SORGHUMS.[b]

All of the sorghums now in cultivation probably originated from a wild species native in tropical Africa.

The sorghums grown in this country may be separated into four groups—(1) the broom corns, (2) sorgo, or sweet sorghums, (3) kafirs, and (4) durras. The broom corns are grown only for their brush. The sweet sorghums are grown for forage and sirups, the kafirs for grain and forage, and the durras principally for grain. The last two groups are generally known as the nonsaccharine sorghums and are especially adapted to the hot, dry, or semiarid sections of the West and Southwest. All the varieties are very resistant to alkali. The durras are especially alkali and drought-resistant and adapted to higher altitudes. They are taller and less leafy than the kafirs. While the kafirs are most largely grown and have the widest adaptation, some of the improved strains of durra or milo are coming into prominence in the drier areas of the Great

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[a] Rice Culture in the United States, by Dr. S. A. Knapp, Farmers' Bul. 110, U. S. Dept. Agr.

[b] See Farmers' Bul. 135, Sorghum Sirup Manufacture; 174, Broom Corn; 246, Saccharine Sorghums for Forage; 288, The Nonsaccharine Sorghums; 322, Milo as a Dry Land Grain Crop; and Cereals of America, by Hunt.

Plains, especially western Texas, New Mexico, Oklahoma, and Kansas.

The ordinary so-called dwarf milo obtainable in the market is the type usually grown, but on account of its lack of uniformity in height of seed heads and bending of the heads it is very difficult to handle by machinery. Improved strains, nonsuckering and uniform, with upright heads and light yellow seeds, have been developed and are being distributed by the Department of Agriculture. These are handled easily by the ordinary harvesting machinery and yield from 25 to 55 bushels of grain per acre. Its value for stock food is slightly less than that of corn, containing a slightly smaller percentage of protein and half the percentage of fat. In tropical countries, however, the sorghums are almost as largely used for human food as rice. In this country their use as human food is principally as griddle-cake flour.

The principal value of the sorghums to the United States lies in their adaptation to conditions where other grain and forage crops are more difficult to produce. The opportunities for improving and adapting the various strains are very great.

It is doubtful whether the sweet varieties can ever compete with sugar-cane and beets for sugar manufacture. They may prove, however, to be a valuable crop for the manufacture of denatured alcohol. As a soiling crop and for hay and silage mixed with legumes the sweet sorghums are superior to the nonsaccharine sorts, though the latter are now principally in use.

It is not a perfectly safe pasture plant on account of the prussic acid likely to develop in second-growth plants or plants which have been frosted or otherwise checked. Sorghum is, however, extensively used for pasture.

BUCKWHEAT.

Buckwheat belongs to the smart-weed family and is adapted to poor soils and short cold seasons. It grows wild on the banks of the river Amur in Manchuria, in Dahuria, and near Lake Baikal. It has long been cultivated in China, northern India, and in the Himalaya Mountains. The species came into central Europe in the middle ages through Tartary and Russia. It was early introduced into America and is quite extensively cultivated in New York, Pennsylvania, Michigan, Wisconsin, and Maine, these States producing four-fifths of the crop in 1899. The acreage and production have been about constant since 1870, when the acreage fell from a little over 1,000,000 to a little over 500,000. It reached 800,000 in 1880, and has fluctuated about this figure to date. The average yield, in bushels, per acre in the United States for 1866 was 21.8 bushels; in 1867, 17.4; for the decade 1868-1877, 17.4 bushels; for the decade 1878 to 1887, 14.1 bushels; 1888-1897, 16.2 bushels; 1898-1907, 17.8 bushels. The table[a] on the following page shows the acreage, production, and value of buckwheat in the United States in 1907, by States.

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[a] Yearbook, U. S. Dept. Agr., 1907, p. 649.

Area and value of buckwheat in the United States in 1907.

State.	Area.	Average yield per acre.	Production.	Average farm price December 1.	Farm value December 1.
	Acres.	*Bushels.*	*Bushels.*	*Cents.*	*Dollars.*
Maine	23,000	28.0	644,000	65	419,00
New Hampshire	2,000	22.0	44,000	75	33,00
Vermont	8,000	22.0	176,000	70	123,00
Massachusetts	2,000	21.0	42,000	70	30,00
Connecticut	3,000	16.0	48,000	75	36,00
New York	325,000	17.5	5,687,000	70	3,981,00
New Jersey	12,000	16.5	198,000	75	149,00
Pennsylvania	257,000	18.0	4,626,000	69	3,192,00
Delaware	1,000	24.0	24,000	69	17,00
Maryland	9,000	19.0	171,000	67	115,00
Virginia	18,000	19.0	342,000	73	250,00
West Virginia	21,000	18.5	388,000	75	291,00
North Carolina	5,000	15.5	78,000	71	55,00
Ohio	13,000	19.5	254,000	75	191,00
Indiana	4,000	15.5	62,000	73	45,00
Illinois	4,000	17.0	68,000	80	54,00
Michigan	55,000	15.5	852,000	65	554,00
Wisconsin	20,000	16.0	320,000	72	230,00
Minnesota	5,000	14.7	74,000	73	54,00
Iowa	9,000	15.0	135,000	80	108,00
Missouri	1,000	16.0	16,000	90	14,00
Nebraska	1,000	14.5	14,000	88	12,00
Kansas	1,000	12.0	12,000	82	10,00
Tennessee	1,000	15.0	15,000	80	12,00
United States	800,000	17.9	14,290,000	69.8	9,975,00

Under favorable conditions, buckwheat will mature a crop of seed in from eight to ten weeks. It will grow at higher altitudes and farther north than any other grain crop. It is not affected by diseases or insects, but is very sensitive to heat and drought. The Japanese variety is the hardiest strain, which with Silver Hull and Common Gray are the types commonly grown in the United States. The flour is used principally for pancakes and as food for hens. Its average farm value is about $11 per acre.

IMPORTANCE OF CEREAL CROPS.

On account of the relatively important position that cereal crops have occupied in the past and always will occupy in the agriculture of the world they have been chiefly discussed individually. The comparative areas and value of cereals in the United States as compared with other field crops is shown in the following table compiled from the Twelfth Census by Hunt:[a]

Area and value of field crops in the United States in 1899.

	Area (acres).	Value of crops.	Value per acre.
Cereals	184,994,598	$1,484,231,038	$8.02
Hay and forage	61,691,166	487,125,685	7.90
Legumes for the seeds	1,964,634	28,308,228	14.41
Tubers	2,938,952	98,387,614	33.48
Roots	537,447	19,876,200	36.98
Sugar plants	855,995	51,367,685	60.01
Fibers	26,401,660	390,879,985	14.80
Stimulants	1,101,483	56,993,003	51.74

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[a] The Cereals in America, by Thomas F. Hunt, p. 3.

Of the total area in hay and forage crops, 6.7 per cent was devoted to clover, 50.7 per cent to tame and cultivated grasses other than clover, 6.3 per cent to grains cut green for hay, 5.1 per cent to forage crops, 3.4 per cent to alfalfa, 2.8 per cent to millet and Hungarian grasses, and 25.1 per cent to wild, salt, and prairie grasses.

The acreage, production, and value of the eight cereals in 1899, and percentage of the total contributed by each, are shown in the following table, taken from the Twelfth Census:[a]

Grain.	Acres.	Bushels.	Value.	Per cent of total acreage.	Per cent of total yield.	Per cent of total value.
All cereals	184,994,588	4,434,698,746	$1,484,231,038	100.0	100.0	100.0
Corn	94,916,911	2,666,440,279	828,258,326	51.3	60.1	55.8
Wheat	52,588,574	658,534,252	369,945,320	28.4	14.8	24.9
Oats	29,539,698	943,389,375	217,098,584	16.0	21.3	14.6
Rye	2,054,292	25,568,625	12,290,540	1.1	.6	.8
Barley	4,470,196	119,634,877	41,631,762	2.4	2.7	2.8
Buckwheat	807,060	11,233,515	5,747,853	.4	.3	.4
Rice	351,344	4,728,710	7,891,613	.2	.1	.6
Kafir corn	266,513	5,169,113	1,367,040	.2	.1	.1

HAY AND FORAGE CROPS.

According to the last census, the total improved farm area in the United States in 1899 was 414,000,000 acres, of which nearly 290,000,000 acres were in crops of all kinds. The difference, approximately 125,000,000 acres, was probably devoted to pasture. This, in addition to the area utilized for cultivated grasses and forage crops, makes the area devoted to these classes of plants nearly 189,000,000 acres—approximately 4,000,000 acres greater than that devoted to all the cereal crops combined. A considerable portion of this land, now in wild grasses and pastures, has in some States formerly been cultivated to cereal and other crops and could now be utilized for that purpose, if necessary, or if such utilization were more profitable than their use for pasture. In some States a considerable portion of this land is mountainous or swampy and under present conditions would probably be utilized only for pasture and hay crops. The percentage of the land thus devoted to wild pasture and hay crops is shown in the census report and the statistics will therefore not be repeated here.

The largest increase in the utilization of this wild-grass land for cultivated grasses and forage has occurred in the West and in the South. In the South the increase is due largely to the fact that large areas which were formerly in many cases under cultivation have been allowed to run wild for long periods, but with the general agricultural progress of the South, the development of stock raising, and the diversification of crops, these lands are being utilized for cultivated hay and forage crops. The production per acre in the Southern States has increased faster than the acreage, which is the result of the use of better agricultural methods, especially the more general use of leguminous crops and fertilizers.

The rapid development of the use of unimproved grass lands for cultivated forage is coincident in nearly all the States with an increase in the live-stock interests, as shown by the census reports. The general summaries, showing the acreage and value of hay and forage crops, compared to the value and acreage of all crops, and the acreage of improved land, is here included to show the very great importance of the hay crops:[a]

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[a] Twelfth Census of the United States, 1900, Vol. VI, Agriculture, pt. 2, p. 14.

States and Territories.	Acreage of hay and forage.	Acreage of all crops.	Acreage of improved land.	Per cent of acreage of—	
				All crops in hay and forage.	Improved land in hay and forage.
The United States [a]	61,691,166	289,821,549	414,793,191	21.3	14.
North Central division	35,676,042	163,000,561	222,314,099	21.9	16.
North Atlantic division	12,919,041	24,683,365	38,920,614	52.3	33.
Western division	7,051,123	16,622,861	27,155,681	42.4	26.
South Central division	3,883,662	56,233,143	80,007,867	6.9	4.
South Atlantic division	2,161,201	29,194,661	46,100,226	7.4	4.

States and Territories.	Value of all crops.	Value of hay and forage.	Percentage value of all crops in hay and forage.	Average value per acre of—		Percentage of total value of hay and forage.
				All crops.	Hay and forage.	
The United States [a]	$2,910,138,663	$484,256,846	16.6	$10.04	$7.85	100.
North Central division	1,373,021,966	221,866,406	16.2	8.42	6.22	45.
North Atlantic division	374,955,069	141,959,434	37.9	15.19	10.99	29.
Western division	192,668,844	60,839,199	31.6	11.59	8.63	12.
South Central division	617,822,833	30,663,233	5.0	10.99	7.90	6.
South Atlantic division	330,370,926	26,926,431	8.8	11.32	13.38	5.

[a] Data for Alaska and Hawaii included in totals for United States, but not in those for the 5 geographic divisions.

The hay and forage crops are made up of a very large number of both wild and cultivated species. On the ranges of the West, and to a considerable extent in the North Central States and the Southern States, wild grasses enter into the composition of the hay, even on lands that are under cultivation. There are about 3,500 known species of true grasses, divided into about 300 genera. Of this number there are in the United States 1,380 species (1,275 native and 105 introduced), divided among 165 genera. Scribner estimates that 38 of these grasses have earned a high reputation as hay grasses, 35 as pasture grasses, 14 as lawn grasses, and 24 as grasses for wet lands, 20 for embankments, and 19 for holding shifting sands, the same grass occasionally occurring in the different categories.

In the census returns the true grasses are listed as (1) wild, salt, and prairie grasses, the total acreage amounting to nearly one-fourth of all the acreage producing hay and forage; (2) the millet and Hungarian grasses, grown especially in the North Central and South Central divisions, but to some extent throughout the United States. The total area reported in this class of grasses was a little under 2,000,000 acres, producing nearly 3,000,000 tons.

Among the millets and Hungarian grasses the best known are the foxtail or common millets, the broom-corn millets, barnyard millet, and pearl millet. The former are the most commonly cultivated, and all of them produce not only a large amount of forage but large quantities of grain. The millets are all hot-weather plants, but are exceedingly drought-resistant. They will grow luxuriantly on poor soils, but respond well to richer soils. Many of these grasses could be easily improved both for seed production and for forage and hay, but so far very little attention has been given to them.

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[a] Twelfth Census of the United States, 1900, Vol. VI, Agriculture, pt. 2, p. 21

Para grass—Recently Para grass, a South American *Panicum*, has given excellent yields along the Gulf coast and in Florida. Its culture is rapidly extending westward, especially in southern Texas. It has a great advantage over Bermuda grass or Johnson grass, as its runners are on the surface and can be easily destroyed, whereas in the grasses mentioned the runners have a tendency to go rather deep, so that they are difficult to eradicate from cultivated land and, for that reason, are much in disfavor. The Para grass, however, can not stand much cold at the present time. It will doubtless, however, gradually be pushed farther north and may become one of the most valuable forage and hay grasses for moist or wet lands. In Florida Para grass has carried as high as 6 head of cattle per acre for eight months of the year.

Guinea grass.—This is a closely related species introduced from Africa. It grows more as a bunch grass, is adapted to drier lands, and is a highly prized grass, especially in Florida, Alabama, and Mississippi.

Crab-grass.—The crab-grass of the South, though considerable of a weed, makes excellent volunteer forage and very good hay.

Bermuda grass.—The most common lawn and pasture grass of the South is the Bermuda grass. It produces a very fine quality of hay, is an excellent sand and soil binding grass on account of its strong rootstocks, stands pasturing well, and is quite resistant to cold.

Bluegrass.—In the North the Kentucky bluegrass is the principal cultivated pasture grass and lawn grass. It is especially adapted to limestone soils.

Timothy and redtop.—In the North the principal hay grasses are timothy and redtop, the former adapted to the higher and drier lands, and the latter to the moister situations.

Other wild grasses.—In the West the principal wild grasses are the blue and white grama, mesquite, buffalo, and the bunch grasses, the big bluestem, and the western wheatgrass. A large number of other genera and species, however, are of great importance as adapted to special conditions, especially to high altitudes, to alkali, and to withstand drought, many of the most valuable species, like buffalo grass, curing as they stand on the ground, making an excellent winter feed.

As previously stated, many of these wild grasses have been almost destroyed in parts of the range country, owing to overstocking, but it has been found that, if the range is rested and if the wild grasses are allowed to seed for a few years, they can easily come back to their former luxuriance. Observations made by Mr. Coville in connection with the Forest Service show that it is often necessary to keep the stock off the range only for a short period, while the more important grasses are forming their seed. After the seed is formed, the range may be again used without serious injury to the grass flora. Taking advantage of this fact promises to be one of the most important elements in range management.

Great improvements can be made by selection, not only in our native grasses, but in the introduced species. Their value and adaptation to certain areas can by this process be very greatly increased. Grasses respond also readily to fertilizers, especially to nitrogen and phosphates.

Next to the legumes, the grasses are the most important soil-improving crops, provided a considerable portion of the stubble or the sod is occasionally turned under or allowed to rot on the ground, thus forming humus. Under these conditions in limestone soils, if the proper bacteria are present, large quantities of atmospheric nitrogen are fixed by the bacteria, the carbon required in the process being furnished by the dead grasses. None of the grasses, however, so far as known, have symbiotic bacteria growing on their roots, as in the case of legumes.

LEGUMINOUS FORAGE CROPS.

Clover.—Of the leguminous forage crops, the most important are the clovers in the Northeast and North Central sections, cowpeas in the Southeast and South Central States, and alfalfa in the West. There are about 250 species belonging to the true clovers, genus *Trifolium*, about 65 of which are native in North America, the greatest number being in the Western States. Many of these are extremely valuable as elements in the native forage and as soil-improving, nitrogen-fixing crops.

The most valuable cultivated species, however, are the introduced varieties—red clover, mammoth clover, crimson clover, alsike, and berseem. Of these the red clover is the most important and the most widely cultivated. It has many strains as the result of cultivation under different conditions, but up to the present time very little attention has been given to selecting and adapting varieties to localities.

Clover requires a well-drained soil containing considerable lime. It is extremely sensitive to acid reaction in the soil or to a lack of potash or phosphoric acid. It also requires, like the other legumes, certain types of bacteria, which form nodules on the roots and secure nitrogen from the air for the use of the plant. Occasionally these bacteria are not present in the soil or are of reduced vitality or nitrogen-fixing power, and clover fails to do well until the soil is reinoculated.

In the South a root and stem disease has destroyed large areas of red clover, and the disease, living in the soil, prevents the growth of clover on those soils. The Tennessee station has found that strains resistant to this fungus can be developed, and such selected strains of clover grow well in soils where the ordinary types die out completely. The large number of species of clovers which hybridize readily makes it possible to produce strains adapted to a very wide range of conditions and agricultural requirements.

Crimson clover is cultivated especially in the South Atlantic States north of the cotton belt and south of the fortieth parallel. It is grown principally as a cover crop in orchards for soil improvement.

In the Southern States the principal legume grown for hay and for soil improvement, as well as for the seed, is the cowpea. There is a large number of varieties of cowpea, probably originally developing from a single species, *Vigna sinensis* (a bean rather than a pea). Unlike the clovers, the cowpeas are well adapted to soils inclined to be acid, but are, nevertheless, prolific nitrogen fixers, provided they are supplied with the proper bacteria. The cowpea, however, is peculiarly subject, on light soils, to attacks from the nematode rootworm, causing galls on the roots, and to a disease known as wilt. The culture of varieties susceptible to these diseases is likely to infect the soil to such an extent that other crops sensitive to these diseases can not be developed, and even the peas themselves fail to grow. The only crops not injured by root-knot are the grasses and grains. The disease is very injurious to vegetables, fruit trees, and cotton, and many thousands of acres have been practically ruined for these crops by the development of nematodes in connection with the cowpea. As the cowpea, however, is absolutely essential as a soil-improving crop, it was necessary to find a strain resistant not only to the nematode but to the wilt. This was accomplished in the variety known as "Iron," which is extremely resistant to both diseases and can be used with perfect safety on soils infected with the diseases or without danger of introducing disease to soils not infected. The Iron cowpea, therefore, is the key to the improvement of the lighter, sandy soils in practically all the Southern States. Its resistant qualities have now been bred into a number of other strains of cowpea, but these have not yet come into commercial use. It is possible, however, to produce resistant strains which give high yields of hay and seed and which are adapted to the various localities. Much interest is now being taken by experimenters in this work.

Alfalfa or lucern (*Medicago sativa*).—This is the most important leguminous hay and forage plant of the West. It was introduced into California from Chile in 1854, and spread first through the irrigated sections. Some of the varieties are especially adapted to irrigated lands, on which they give extremely high yields. It has been grown more or less in every State of the Union, although it is only in the West and Southwest that its culture has reached large proportions. Until very recently alfalfa was supposed to be practically one species, but more careful study has shown that there are probably several species and a very large number of varieties, much of the commercial seed being considerably mixed.

The ordinary alfalfa or purple lucern is widely cultivated all over Europe and Asia and has hybridized to some extent with other species native in those regions, especially with the yellow form, *Medicago falcata*, growing in the north of Europe. The latter species has yellow flowers and is extremely cold resistant. These hybrids, known as *Medicago media*, combine the fine hay qualities of the ordinary alfalfa with the cold and drought-resistant qualities of the yellow northern form and are thus much better adapted for growth in such localities. Some of these hybrids are known under the common name of sand lucern and are found to be well adapted to northern Michigan, Minnesota, the Dakotas, and Montana. A similar intermediate form has been found in Turkestan, and is probably a hybrid between the yellow form of northern Siberia and the dry-land strains of the ordinary alfalfa growing in Turkestan.

Alfalfa adjusts itself to climates and soils with considerable facility and, where it has long been cultivated under peculiar climatic conditions, it adapts itself to these conditions. Extremely valuable sorts or strains may thus be secured from many Old World localities, and these strains when introduced into similar conditions in the United States are proving of more value than the ordinary unadjusted or unadapted sorts. It is absolutely essential, however, in introducing these strains to know the exact conditions to which they are adapted; otherwise they will simply break up and require acclimatization again. An American adaptation of this kind has been found in northern Minnesota and has been distributed under the name of Grimm alfalfa. This is an acclimatized strain of ordinary alfalfa, possibly having a slight admixture of the northern yellow species *falcata*. In any case, it is an extremely valuable cold-resistant sort.

A strain of alfalfa secured in an oasis of the Sahara Desert is extremely alkali resistant and may prove valuable for such locations.

A careful study of the varieties and adaptations of this important class of leguminous crops is now being made by the Department of Agriculture, experiment stations, and practical farmers, and great improvements will undoubtedly soon be made in the adaptation of these varieties to varying conditions. There is no doubt that strains well adapted to culture in the Eastern and Southern States can be developed. The alfalfas are perennial, deep-rooted crops, strong nitrogen fixers when supplied with the proper bacteria, and extremely valuable not only for forage and hay but as soil improvers, making large amounts of humus and fixing large quantities of atmospheric nitrogen.

The nodule bacteria adapted to alfalfa are rather more sensitive to unfavorable soil conditions than the types adapted to other legumes, and greater difficulty is therefore found in inoculating seed for sowing in areas where the germ is not present. For this reason inoculation with soil has proved more certain in many cases than culture inoculation, and where soil can be obtained free from injurious weeds or diseases this method is to be recommended.

The worst pests of alfalfa, however, are weeds, especially the dodders and wild barleys and other grasses. The alfalfa leaf-spot and anthracnose (the same disease which attacks clover) are often quite destructive in the Southeastern States, where root nematodes also do considerable damage to this crop. In the Southwest the root-rot, *Ozonium*, which attacks cotton, also attacks alfalfa, and, as all these pests are readily distributed through soil, it is considered a dangerous practice to distribute soil for the purpose of inoculation, except from very carefully controlled fields, which are hard to find. The Department of Agriculture supplies pure cultures, and with a little care these can usually be made to work satisfactorily. Wherever sweet clover grows the sweet-clover germ present in the soil works satisfactorily on alfalfa, so that inoculation is not usually necessary.

The vetches.—Two of the twenty or more species of vetches have been used considerably in this country as cover crops and for soil improvement and hay—spring vetch or tare (*Vicia sativa*) and the winter, hairy, or sand vetch (*Vicia villosa*). The former is cultivated to some extent in New England and in Washington, Oregon, and California. The winter vetch, or hairy vetch, is much better adapted to the agricultural requirements of a winter cover crop than the former species and is coming to be widely used for that purpose.

Very cold-resistant strains of this winter vetch have been introduced from northern Europe and have been adjusted to the conditions in New England. It also grows quite successfully through the Middle States and the South. It produces a mass of fibrous roots, which when inoculated produce abundant root tubercles. It does not seed well unless inoculated. Although it does best on good soil it makes an excellent growth on poor sandy, gravelly soils, where it produces a heavy growth of nodules.

The importance of inoculation on poor soils is shown by the results secured at the Alabama station. Without inoculation it produced only 232 pounds of hay per acre, but with inoculation it produced 2,540 pounds. At the Cornell station over 6,800 pounds of air-dried forage per acre were produced in three months, and even higher yields than this have been produced in many localities. This winter vetch is not only cold resistant, but also resists drought and is not subject to serious injury from diseases or insects. It is, therefore, one of the most promising of our winter cover crops both from the standpoint of soil improvement and forage as well as hay.

Other valuable legumes.—In the cotton States the velvet bean (*Mucuna utilis*), the Florida beggarweed (*Desmodium tortuosum*), Japan clover (*Lespedeza striata*), and the bur clovers (*Medicago maculata* and *M. denticulata*) are all valuable cover crops.

A large number of other legumes, both native and introduced, are being experimented with by department and experiment station workers, and it is believed that leguminous cover crops and soil-improving crops can be found for every locality and condition required. These, with the proper bacteria present, ought to supply not only the soil humus so necessary to the maintenance of fertility, but they should fix from the atmosphere the nitrogen required for our other cultivated crops and grasses. The improvement of these leguminous cover crops is rapidly being pushed, and as agricultural conditions settle down to greater permanence their use in rotations will be greatly increased.

In this connection should be mentioned also legumes grown for seed. These are also valuable soil improvers, as, after the seed is gathered, the hay can either be used for stock feeding or turned under. All of the legumes already mentioned are more or less grown for seed, but in addition to these the common pea in its various varieties, the cowpea, the soy bean, peanut, and horse bean (*Vicia faba*) are all largely cultivated. There is a very great number of varieties of these crops adapted to different conditions, all of which can be very greatly improved by breeding and selection.

SUGAR-PRODUCING CROPS.

Sugar beets.—Of the root crops the most important are the various varieties of beet. Some of the white varieties of beet contain high percentages of sugar and are cultivated under the name of sugar beets, especially in the North Central and Northwestern States, where the days are cool and bright. Formerly the seed for the highly selected strains of sugar beets was imported, but in late years, through the effors of the Department of Agriculture, strains have been developed specially adapted to the northwestern conditions, which give better results than imported seed.

The principal drawback to sugar-beet culture in the United States is the large amount of hand labor required in thinning the beets, as the seed balls have from two to five germs in each ball and all but one of these has to be broken off after the seed sprouts. The department has under way a breeding experiment for the production of single-germ seeds, so that each ball will produce but one sprout. Strains have already been secured which produce more than 60 per cent of these single-germ balls, and it is believed that ultimately strains of high sugar-producing sorts of beets can be developed which can be planted by machinery and thinned by machinery, thus greatly reducing the amount of labor in the culture of this crop. When this is accomplished, the industry of sugar-beet growing in the United States will be very greatly stimulated, and it is possible that not only our home demand for sugar can be supplied but that we can compete in the foreign markets.

Sugar cane.—The sugar cane of the South is also an important sugar-producing plant, but very little attention has yet been given to its improvement. From the results of work done in the West Indies and to some extent by experimenters in this country, it seems probable that considerable improvement can be made in the productiveness and unformity of American cane.

The soil and climatic conditions of Louisiana and the cane-growing sections are not as favorable to the growth of this crop as are those of Cuba, Porto Rico, Hawaii, and other tropical islands. The cost of drainage and the occasional cold waves, the high cost of seed cane, and the lower yield per acre in Louisiana, make the cost of sugar per pound very much higher than in the other countries named. Unless some improvement can be made in the methods of handling this crop in the Southern States it is doubtful if it can do much more than hold its own in competition with other cane sections now in possession of the United States. As shown by the census reports, the development of the sugar industry in Hawaii has been phenomenal since close trade relations have been established between the islands and the United States. With the development of irrigation works it is probable that considerable land not now cultivated can be brought under cultivation for cane and that the amount of sugar supplied by the islands can be considerably increased. The same is also true in Porto Rico, the Philippines, and Cuba.

According to the latest statistics gathered by the Department of Agriculture, the production of the cane sugar appears to be about just holding its own from year to year, while the production of beet sugar has considerably more than doubled in six years. The total annual consumption of sugar in the United States has reached nearly 3,000,000 long tons, and about 80 per cent of this is imported either from foreign countries or from the insular possessions of the United States. The total consumption of sugar has increased about 140 per cent, while the per capita consumption has increased 52 per cent since 1884. It is evident, therefore, that there is great opportunity for the development of the sugar industry not only in the United States but in our insular possessions.

Saccharine sorghums.—Another source of possible sugar production on the basis of farm crops is in the utilization of the saccharine sorghums. These have already been briefly referred to and attention called to the difficulties of obtaining from sorghum cane cheaply a good quality of sugar. The juice of the sorghum cane, as extracted by the mill, shows, in addition to sugar and water, considerable starch, dextrine, and soluble salts, which interfere with the crystallization of the sugar. Some of the better quality of cane, however, contains over 12 per cent of cane sugar and only 0.6 per cent of glucose. Almost no attention, however, has ever been given to the question of the careful breeding of canes for the purpose of cane-sugar production. With improvements in the methods of extraction which have been made in the past few years, especially through the efforts of the Department of Agriculture, and with the improvements which will be entirely possible as the result of careful selection and breeding, it is believed that the growing of sorghum cane for sugar will in the future be fully as profitable in the Southern States as the culture of beets in the Northern, and this crop may be considered as one of the important potential sugar crops of the United States. The cane is now cultivated in small areas on nearly 500,000 farms in the South, but it is used principally for sirup. These figures do not include a considerable acreage of the saccharine sorghums grown for forage. Nearly 17,000,000 gallons of sirup were produced in 1899, valued at over $5,000,000.

Maple.—According to the last census, the quantity of maple sugar made in the United States in 1899 was nearly 12,000,000 pounds and over 2,000,000 gallons of sirup.

FIBER CROPS.

Practically all of our cultivated plants produce more or less valuable fiber. The immense quantities of cornstalks now going to waste, in addition to what are used for other purposes, produce very valuable fibers for paper manufacture, and recent investigations and discoveries have led to the belief that the stalks may possibly be utilized to replace wood pulp now largely used in cheap paper manufacture. A method of separating the pith from the fiber cells has recently been discovered which appears to make the utilization of stalks for this purpose practicable.

Flax.—The oldest of our fiber plants is probably flax. Flax culture was early introduced into America, but has always been conducted along the most primitive lines. The farm methods have been crude and very irregular; the crop was grown year after year on the same soil without rotation, so that even at the present time the crop has no permanent place in the agriculture of the country. It is usually grown on new land for one year, sometimes two, after which the soil is said to be "flax sick" or exhausted, and the crop is moved to a new area. In this way it has been an important crop in a number of the older States, gradually moving westward to new lands, and is now centered in North Dakota and South Dakota.

The total area of flax in the United States is in the neighborhood of 3,000,000 acres (1907). There is considerable fluctuation in the acreage from time to time. In 1903 it was approximately 3,700,000. In this country flax is grown almost entirely for its seed for the purpose of extracting the oil. Between 25,000,000 and 30,000,000 bushels are annually produced, with an average yield fluctuating between 8 and 11 bushels per acre.

One of the principal reasons that the fiber has not been utilized has been the fact that the crop must under present agricultural conditions be grown on new land, and for that reason the center of production has been in constant movement from year to year. It has now been discovered, however, through the work of the North Dakota Experiment Station that flax sickness is not due to the exhaustion of the soil, but to the presence of one of the wilt fungi, a parasite which getting into the roots destroys the plants. This wilt fungus is very closely related to the one causing the wilt of cowpeas, cotton, and other crops in the South. A strain of flax resistant to this disease has been developed and produces excellent crops on infected soils where the ordinary flax will not grow. This promises to establish flax culture upon a firm basis, and, with the development of general farming systems, including rotation methods, and improvement of the fiber qualities of the flax, it is believed that strains valuable not only for oil but for fiber can be very profitably grown, at least in the moister portions of the North Central States.

The finest varieties of fiber require rather moist air and soil not subject to severe drought, and with a high humus content. It is probable, therefore, that the finest fiber flaxes will be produced in the moister portions of the country, while the oil or seed flax may be more successfully grown in the drier sections. However, even the straw in the drier regions can be utilized for tow, for paper pulp, binder twine, crash toweling, bagging, etc., and, as the industry becomes more stable, factories are developing to utilize the waste straw in this way.

COTTON.

The fiber plant of greatest importance, not only to America but to the entire world, is cotton. There are about 24 recognized species of cotton in different parts of the world. Many of the species cross readily, so that wherever they have been brought together there are many intermediate types. The American Upland cotton, which constitutes the bulk of the cotton of the world, comes from a species (*Gossypium hirsutum*) native in Central America. The plant is a perennial but both in its native habitat and in the United States it is cultivated as an annual.

Sea-Island cotton.—The Sea-Island cotton, *G. barbadense*, is apparently indigenous in the West Indies. It is of larger growth than the upland cotton and has a much longer and finer fiber. Its culture is practically limited to the moister coast regions of the South Atlantic States, the finest grades of it being produced on the sea islands in the neighborhood of Charleston and in the more healthful portions of the coastal plain in Alabama, Georgia, and northern Florida. The average production for the past seven years has been about 94,000 bales annually. The plant requires the most careful selection in order to maintain the high quality of the fiber. A few years ago many of the finest soils for this plant in the sea islands became unprofitable for the growth of this crop, the cotton dying before maturity. This was at first supposed to be due to the exhaustion of the soil in some particular, but investigation showed it to be due to a wilt fungus similar to that attacking cowpea, and resistant strains of Sea-Island cotton were bred which produced excellent crops even on the worst infected land. This again placed the industry on its feet, but the growers in the sea-island region have combined and allow no seed of their selected strains to be sold outside the district.

The sea-island growers outside the district have not been so progressive in the matter of selection, but are waking up to the necessity now that they can not secure seed from the Charleston district. Through the efforts of the Department of Agriculture it has been demonstrated that the strains for inland culture can be improved in the same manner as the Sea-Island strains and that wilt resistance, which is as fully if not more important in the interior districts, can be developed and maintained by selection.

The demand for Sea-Island cotton is somewhat limited, and excessive stimulation of production is therefore not desirable, as much reduction in price would make the crop unprofitable owing to the great care required in its production.

Egyptian cotton.—A closely related type of cotton, if not the same, is the Egyptian. The Egyptian cottons are cultivated principally in Egypt, but considerable quantities are imported into this country for special uses. The plant has now been acclimatized in the irrigated regions of the West and yields an average of a bale to the acre of a very good quality of fiber, but has not yet reached the stage of commercial production. About 100 bales will be marketed during the present season.

Long-staple Upland cotton.—The only other long-staple cottons produced in the United States are the so-called long staple Uplands now grown mainly in the alluvial delta region of Mississippi and Louisiana and to a limited extent in the rich valleys of the Red River in Texas and Louisiana and in similar localities in other cotton States. The crop of these cottons constitutes about 100,000 bales. The origin of the long-staple Uplands is probably the result of hybridization between the ordinary Upland cotton and the Sea-Island species. A number of fairly well-known strains are now in culture—Allen Hybrid, Allen Improved, Cook, Doughty, Griffin, Improved Long Staple, Mathews, Moon, and Columbia (the latter developed by the Department of Agriculture), Peeler, Southern Oak, Sunflower, and other varieties. Little attention has been given to the development of long-staple strains, as the premium paid for them has not been sufficient to warrant. The Sea-Island blood in them has had a tendency to make the long-staple strains rather late in maturing, which has not up to the present time been a drawback, but now that the boll weevil has such a firm foothold it will either be necessary to develop strains of the long staples of quicker maturity than those now grown or give up the culture of these cottons altogether, as production in the presence of the weevil demands quick maturity. The department has developed some hybrids between Upland and the long staples which appear to be as quick maturing as the Uplands and have done well in the river bottoms of southeastern Texas, maturing sufficiently early to escape serious injury from the weevil.

Upland cotton.—The great bulk of American cotton, however, as previously stated, comes from the Upland sorts, of which there is a large number. Cotton adjusts itself gradually to variations in soil and climate, and to secure the best results it is necessary to carefully select and breed seed in the region where it is to be grown. Almost no attention, however, has been given to this matter in cotton culture. The practice has been to get seed from the gin, and therefore mixtures of different strains were secured, often of poor quality and low yielding power, with the result that the average yield throughout the cotton States is very greatly below what it could easily be made by a little care in the selection of seed and the adaptation of the strains to the conditions of culture. Since the advent of the boll weevil much more attention has been given to this subject, and strains have been developed and improved both for quick-yielding and maturing qualities as well as for high quality of fiber or lint. Quick-maturing strains, like Triumph and King, have given very satisfactory yields even in the presence of the boll weevil, maturing the crop early enough to escape serious weevil injury.

In the original home of the American Upland cottons it has been found by department investigators that there are varieties of cotton having adaptations which enable them to resist weevil attack. The more promising strains of these have been brought into the country and are being tested both for their use in breeding and for their individual value for cultural purposes, and as these types were the originals from which the American cottons came, it is probable that some valuable characters can thus be secured, especially along the line of avoiding weevil injury.

Upland cotton is also subject in the Southeastern States in sandy soils to the same disease that attacks the Sea-Island cotton, namely, the wilt. The disease is quite widely spread and annually causes a large loss. Two types of Upland cotton resistant to this disease have been developed and are now being distributed by the department. These types give excellent yields on soils infected with the disease, as well as on other soils.

Cotton responds readily to selection and to better cultural methods. For many years the crop has been grown without rotation and with very shallow and imperfect cultivation and the use of large quantities of commercial fertilizer. All of these practices have resulted in the depletion of the soil humus to such an extent that the soil now packs and washes badly in nearly all the cotton States. It has been demonstrated, however, by good farmers and by numerous experiments by the state stations and the Department of Agriculture, that the plowing under of legumes and the use of barnyard manure and winter cover crops will quickly improve the soil by increasing its humus content, so that with much less commercial fertilizer it will produce more than double its present yield of cotton. These methods, coupled with more attention to the selection of seed, could easily raise the yield of cotton to more than double the present figures on the same acreage, and at the same time produce a number of other valuable money crops in rotation.

The United States now produces nearly 11,000,000 bales, which is more than 65 per cent of the total cotton crop of the world; British India produces something over 2,000,000 bales, a little over 14 per cent of the world's crop; Egypt produces a little over 1,000,000 bales, nearly 8 per cent of the world's crop; Russia, China, Brazil, Mexico, Peru, Turkey, Persia, and several other countries produce small amounts of more or less special types, for which there is a comparatively small demand. It is not probable that any other country will ever seriously compete with the American Upland cotton, especially if some attention is given to the improvements above suggested.

Miscellaneous fiber plants.—A large number of other fibers, including hemp, jute, ramie, etc., could be produced and are grown to some extent in the United States, but their importance has not been sufficient up to the present time to make them compete with other more valuable crops. Hemp is the most important of these and is grown to a considerable extent in Kentucky.

DRUG AND MEDICINAL PLANTS AND NARCOTICS.

The culture of drug and medicinal plants has not been developed extensively in the United States, but interest in this class of crops has been growing in recent years.

Camphor.—It has been shown that camphor can be profitably produced in Florida, the Carolinas, and possibly in Texas, and the beginning of an important industry in the growth of this tree is now apparent.

Opium poppy.—The culture of the opium poppy, which has heretofore been confined in this country simply to the production of poppy seed, will be stimulated to some extent by the discovery of a direct process of extracting morphine from the capsules, leaving out entirely the opium stage, which is so objectionable. This industry will be best adapted to the sections where the poppy is now grown principally for seed, namely, California, Oregon, and Washington.

Other drug plants.—A large number of other native and introduced drug and medicinal plants have been tested in different sections of the country and small industries in their culture will doubtless soon develop.

Tea culture.—Of the narcotics, tea has been commercially produced in South Carolina, and the extension of its culture will depend largely upon the development of machinery to supplement hand labor and reduce the amount of hand labor required. This has now been accomplished in practically all of the curing processes, and one of the department experts has about completed a pruning machine, and a picking machine will soon be developed which will practically reduce the production of tea to a machine basis. When this is accomplished it ought to become as important a crop in the South as tobacco.

Tobacco.—At the time of the discovery of America, tobacco was used for smoking, for snuff, and for chewing by nearly all the tribes of Indians in North America and Central and South America, including the West India Islands. There are about 50 species of the genus *Nicotiana* found in the wild state. All but two of these are found in America. The culture and use of tobacco undoubtedly originated in very early times on this continent, and from the earliest settlement it has been an important crop in several of the New England, Central, and Southern States. Practically all of the cultivated agricultural varieties originated from the species *Nicotiana tabacum* from South America. It is possible, however, that some of the strains may have the blood of a species which grows wild in Connecticut, New York, and Colorado, *N. rustica.* In the early days of the industry, especially in Maryland and Virginia, tobacco was grown year after year on the same land until the soil failed to give profitable returns, when the land was abandoned and allowed to grow up to brush and wood. Many thousands of acres of such old abandoned tobacco farms are still to be seen in these States now mostly covered with old field pine.

As tobacco is cultivated for the texture, size, and quality of the leaf, it is very greatly influenced by conditions of soil and climate, and the greatest care has to be exercised in the selection of soils for the production of the finer varieties, especially the cigar tobaccos. Most of the varieties now in cultivation are adaptations to peculiar soils and climates, and through long culture have come to be well-established types adapted to different uses. Among these may be mentioned the cigar-wrapper types, the cigar fillers, the chewing and plug, and the heavy export types.

Of the cigar-wrapper tobaccos the so-called Sumatra type, which produces a medium-sized, thin, elastic leaf when grown on light well-drained soils in the Connecticut Valley, Florida, and southern Georgia, is the standard. This variety produces the best grade of domestic cigar wrappers. It is grown under shade extensively in Florida and southern Georgia, and recently types have been secured which give satisfactory results in Connecticut. The so-called "Uncle Sam Sumatra," which is a strain of this type produced by the Department of Agriculture, is said to be the most uniform and highest yielding strain of Sumatra ever produced and is now cultivated extensively in Florida and to a considerable extent under shade in Connecticut. Connecticut Havana is a variety largely used for cigar wrappers and binders and the poorer leaves for fillers. It is adapted to light sandy soils when grown for wrappers, and to clay soils when grown for fillers. The light soils make the leaf thin and elastic, while the clay soils make the leaves heavier, thus producing a leaf better adapted for fillers. The Connecticut Broadleaf or Connecticut Seedleaf is a type very largely grown in outdoor culture in Connecticut and is adapted to sandy loam soils. The leaves are very broad, thin, and elastic and have small veins. The quality of wrapper and binder secured from this type of tobacco is not as good as that from the other types mentioned, although it has high yielding power and its adaptability for culture under northern conditions makes it a very desirable leaf for Connecticut, New Hampshire, Vermont, New York, Pennsylvania, Ohio, Wisconsin, and to a small extent in other States. Its quality has recently been very much improved in certain hybrid types between this tobacco and the Havana developed by the Department of Agriculture. It is believed that these new hybrids, which are now beginning to be grown in Connecticut and New York, will ultimately replace the old types.

Of the cigar-filler tobaccos the Cuban variety is the leading type adapted to sandy soils with a clay subsoil; has a small leaf of fine texture and produces a fine flavor and aroma. In the Connecticut Valley this type is also grown under shade for wrappers as well as fillers. Zimmer Spanish, which is probably a hybrid between the Connecticut seed leaf and a Cuban variety, is the principal cigar-filler tobacco grown in the Ohio Valley and Wisconsin.

Of the plug tobaccos the White Burley, the Orinoco, and Yellow Mammoth, and the Virginia tobaccos, Blue Pryor, Sun-Cured, and White Stem, are the leading types, grown especially in Kentucky, Ohio, Tennessee, and North Carolina.

Of the pipe tobaccos the bright yellow types of North Carolina and southern Virginia are leading sorts. These tobaccos are produced only on light sandy soils. On heavier, richer soils they produce a dark-curing leaf. The demand for this type of tobaccos is rapidly increasing, especially for export. The Maryland smoking tobaccos are largely export tobaccos. They develop best on clay loam and sandy soils. The leaves are thick and coarse in texture. The variety was discovered in Maryland when the first settlers explored the region and has extended from Maryland to Virginia and Pennsylvania, and from this type quite a number of important strains have developed in these States.

In recent years great attention has been given to the fertilization of tobacco, especially the finer wrapper and filler sorts. On account of the influence of soil on the quality of the leaf the tendency has been in all the areas producing the finer wrapper and filler tobaccos to grow the crop continuously upon the same land without rotation, and, although great care is used in the composition of the fertilizers, the tendency has been to use excessive amounts. The wrapper and filler types of tobacco do not grow to the best advantage on soils rich in carbonates, so that soils very rich in lime have to be avoided for this class of tobacco. In the Connecticut Valley the extensive use of carbonate of potash and other fertilizers containing carbonates has resulted in the accumulation of these to such an extent in the soil that the feeding roots of the tobacco have been slightly injured, making them sensitive to a fungous disease, which in the past few years has greatly reduced the yields over large areas. The fungus occurs commonly in leaf-mold and decaying organic matter and to some extent on injured roots of tobacco, but does no harm except when the soil becomes decidedly alkaline. It has been found that by using no lime on the diseased fields, applying potash in the form of the sulphate and using phosphoric acid in the form of the acid phosphate or dissolved bone, the alkalinity is overcome and the disease prevented.

The method of culture and fertilization followed has also in many soils very greatly reduced the humus content. This in some cases has been partially avoided by the use of barnyard manures, but on the finer types of leaf these manures stimulate too rank a growth. Experiments conducted in the past few years by the department have demonstrated that hairy vetch used as a winter cover crop for tobacco soils greatly improves the leaf texture, supplies the necessary nitrogen and humus, and improves the soil greatly for the production of the better types of leaf. Yields of over 7 tons of vetch per acre have been secured from inoculated seed. The nodule organism for vetch is not found in tobacco soils generally and the crop does not give good results except where the germ is supplied. Tobacco following uninoculated vetch shows but little advantage over that following a cover crop of rye. In comparative tests the inoculated crop yielded 7 tons as compared with the yield of 2 tons uninoculated, and the nitrogen content of the inoculated crop was very much higher than that of the uninoculated. Where a sufficient supply of humus is present in the soil the tobacco crop is not only larger but better in quality and more uniform.

In the South a bacterial disease has accumulated in some of the tobacco soils as a result of continuous culture without rotation, and in some places root nematode has developed to such an extent that the soils will no longer produce a profitable crop. In the latter case a resistant strain of tobacco has been produced by selection which grows well on nematode infected soils, but no strains resistant to the bacterial disease have yet been secured. The same bacterial disease also attacks potatoes and tomatoes, which are among the profitable crops grown on the same soils in Florida. It is useless, therefore, to rotate with these crops where this disease is present.

In the areas growing heavier types of tobacco, especially in Maryland, Ohio, Kentucky, Virginia, and the Carolinas, the principal problems involved in the improvement of the crops are along the line of rotation. The tendency is to cultivate tobacco too long upon the same land without rotation and without proper fertilization. The experiments conducted by the department have shown that the yield can be very greatly increased by rotation systems and by the use of fertilizers where the lands are deficient in any of the necessary elements, as they often are in nitrogen, potash, and phosphoric acid. In all sections the experiments have shown that great improvements can be made in the tobacco crop by careful selection. Tobacco is cross-fertilized by insects, so that in order to secure uniformity in product it is necessary to prevent insect visits to the flowers. In view of the fact that the tobacco is perfectly self-fertile, this is easily accomplished by bagging the flower stalks before the flowers open. In this way, by carefully selecting the mother plants, it is possible to produce improved strains of great uniformity, and as a few plants produce all the seed required for a large crop, the use of this bagging system, introduced by the department several years ago, has already resulted in the development of strains of superior quality and much higher yield.

The work of the department has also demonstrated that it is possible to separate the light from the heavy seed in order to produce greater uniformity. A simple device for this purpose has been patented by the department and is now in wide use among the tobacco growers.

Great improvements in the quality and quantity of the marketable crop have been secured by better methods of curing and fermentation. A discovery made by one of the department experts of the relation between nicotine and the quality of tobacco has shown that the sharp biting quality which the leaf often has is due to an excess of free nicotine, and that in the better types of tobacco, although the total nicotine may be equal to or higher than the biting types, it is combined with an organic acid, usually citric or malic. Spraying the leaves during fermentation with a dilute solution of these acids, sufficient to neutralize the free nicotine, greatly improves the quality of the fermented product in cases where the normal citric acid content of the leaf is not sufficiently high to accomplish this.

The production of wrapper and filler tobaccos has been rapidly extended of late years in Florida, Georgia, Alabama, and Texas. Many farmers have gone into the culture of this crop without due consideration of the difficulties involved. The result has been that in the last two years, especially, large quantities of low-grade leaf have been produced—due in part also to unfavorable seasons—and much of it still remains in the hands of the farmers, there being no sale except for the better qualities. This illustrates the danger of too rapidly expanding the culture of a crop requiring such skill and judgment as the production of tobacco of the higher grades.

The total acreage of tobacco in the United States has considerably decreased since 1903, the 1907 area being about 200,000 acres short of the acreage for 1903. The average yield per acre, however, has gradually increased, though the total production as the result of decreased acreage is slightly less than in former years. The average farm price per pound, however, has gradually increased. The domestic exports have remained fairly constant, while the imports of manufactured tobacco have slightly increased. Both the area and the yield in all our types of tobacco can be readily increased as fast as the demand warrants and the price is remunerative.

Hops.—Brief attention should be called to hop production. The United States is becoming an important hop-producing country, though the quality of American hops is somewhat inferior in the estimation of some to certain types produced in Europe. Little attention has been given to the improvement of varieties, and preliminary studies indicate that great improvements can easily be accomplished in quality and in yield. The quantity produced in the United States ranges between 40,000,000 and 60,000,000 pounds annually. The export trade in hops is gradually increasing, nearly 17,000,000 pounds having been exported in 1906. The imports of special qualities of hops, however, amount to between 6,000,000 and 10,000,000 pounds.

POTATOES.

Irish potatoes (*Solanum tuberosum*).—The species to which the potato belongs has been cultivated in the high plateaus of Peru for probably two thousand years or more. It was carried from Peru to Spain, from which country it was probably introduced into North America. Since the discovery of America the potato has rapidly spread into all countries to which it is adapted, especially the cooler temperate regions, until it has become one of the most extensively grown and most valuable food crops of the world, with an annual yield of approximately 5,000,000,000 bushels. According to Fraser,[a] 1 acre of potatoes frequently furnishes as much human food as 10 acres of wheat. Wherever wheat is a precarious crop, as in northern Europe, potato growing has been extensively developed. Yields of 1,000 to 1,200 bushels of potatoes per acre, containing 10,000 pounds of starch, are on record. The average yield for Russia is about 95 bushels per acre; Germany, about 200 bushels; England, 230 bushels; Ireland, 150 bushels. The United States produces approximately 3,000,000 acres per annum, with an average yield for the past ten years of 86 bushels annually. The average yield for 1904 was 110.4 bushels per acre and for 1906, 102.2 bushels. The average yield fell down to 65 bushels in 1901, the crop being badly affected by drought in that year in several of the heavy-producing States. The highest average yields are secured in the New England States and in the irrigated portions of the Rocky Mountain and Pacific Coast States.

The potato does best on a deep, mellow, easily worked loam containing a rather high humus content. Ten or fifteen tons of barnyard manure per acre, plowed under in the fall, or cover crops of buckwheat, clover, hairy vetch, or other similar green crop, put the soil into excellent condition for potatoes. However, in all cases the organic matter should be in a thoroughly decayed state before the crop is planted. In the case of old sods there is danger from grubs and wireworms, so that the cover crop for potatoes should not be more than one or two years old. Where buckwheat does well it is considered an especially good cover crop for potatoes, as it leaves the soil in excellent tilth, and remarkably smooth tubers are produced following this crop. Some of the finest potato soils in the United States are the reclaimed tule peat lands of California.

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[a] S. Fraser; Cyclopedia of American Agriculture, 1907, vol. 2, p. 520.

In all the potato districts there is a tendency to grow the crop year after year on the same soil, with the result not only of humus destruction but the accumulation of several serious diseases of the potato, especially the wilt disease, the bacterial disease, and in the Northeastern States the potato rot and scab. The latter disease is especially caused by the alkalinity of the soil, developing best in soils of an alkaline reaction. The yields during some years and in some sections are often very greatly reduced by these diseases. When the soils become thoroughly infected with these parasites it is difficult to eradicate them, as many of them live for long periods saprophytically. Some progress has been made in selecting varieties resistant to these diseases, but so far the work has had very little effect on the commercial production on account of the fact that no varieties have been developed which have a good market demand and which are at the same time disease resistant.

In the North Central States the so-called early and late blights, due to fungi attacking the leaves, cause in years favorable to these diseases very great loss, but it has been shown that by spraying the crop with Bordeaux mixture it is possible to reduce these losses to a negligible quantity. However, spraying methods are practiced only by the more progressive growers. The same treatment prevents the injury from flea beetles, which otherwise do great damage to the crop, and the use of Paris green with the Bordeaux mixture also prevents the attack of the potato bug, which also does immense damage to crops not protected.

Potato culture is considerably practiced in the South for early markets by importing seed tubers from the North. Southern-grown potatoes are not satisfactory for seed, as the crop is not adapted to hot climates. It is believed, however, that strains could be adapted for culture in the South by the development of seedlings in that region and possibly by hybridizing the *Solanum tuberosum* with some of the other tuber-producing species, as *S. maglia*, which is a native in the coasts of Chile, or *S. commersonii*, a native in Uruguay and Argentina, in rocky and arid situations at low levels. Of the 1,000 species of the genus *Solanum* in many parts of the world, there are about 20 species which bear tubers. It is possible that by combining these with the valuable qualities of the species at present in cultivation its range and adaptation can be very greatly increased, and possibly the food value, especially the nitrogen content of the tubers, can also be improved by this process.

Until within recent years most of the culture of potatoes has been carried on by hand, but potato planters and diggers have now been adapted to this crop, thus greatly decreasing the cost of production.

Sweet potatoes.—The sweet potato, *Ipomoea batatas*, is a member of the morning-glory family and is one of our important vegetable crops of the Southern States. The species from which the sweet potato developed, while not now positively known in the wild state, probably originated in Central or South America, possibly in Peru, where there are records of its ancient existence. It is, therefore, essentially an American crop, but, like the ordinary potato, its culture has extended into many other countries. Related species occur in China and eastern Asia, and its cultivation there may have been coincident with that in South America.

The commercial production of sweet potatoes in the United States extends as far north as middle New Jersey and as far west as Kansas. It is grown extensively under irrigation in southern California. According to the Twelfth Census, the sweet potato is, next to the Irish potato, the most extensively grown vegetable in the United States, and was reported on more than 1,000,000 farms. The acreage, including that of yams, was 537,447, and the value of the crop in 1899 was nearly $20,000,000. The largest production is in North Carolina, Georgia, Virginia, Alabama, and South Carolina.

The sweet potato requires a warm, sandy, well-drained soil, and responds well to fertilizers and manures. A high humus content is essential, as the crop suffers quickly from drought. Crimson clover sod is especially valuable if plowed under while the clover is young. With heavy manuring and fertilizing, sweet potatoes may be grown upon the same land for several years, and this practice is often followed. Several serious diseases, however, result from this practice, especially the so-called black-rot of the roots. The disease does not do so much damage in the field, but when the land becomes infected its presence in the stored potatoes causes them to rot, and in this way it is very injurious. As a rule, however, sweet potatoes are remarkably free from enemies.

The yield per acre depends largely upon the favorableness of the soil, fertilization, and the care and culture of the crop. The yield per acre in the United States averages about 83 bushels for white farmers and about 67 bushels for colored farmers. Yields of three or four times this amount, however, are easily secured where conditions are favorable. The crop is one of increasing importance and is susceptible of great improvement, not only in the matter of varieties but in cultural methods.

The food value of the sweet potato is higher than that of the Irish potato, and its use for feeding to stock is increasing. The principal use of the sweet potato is for the table, and the demand is rapidly growing, especially on the cotton and tobacco lands in rotation with corn, peanuts, and grass.

CASSAVA.

This crop, belonging to the same family as the castor bean, is widely cultivated in the tropics and is probably native to Brazil. The roots produce large quantities of starch as well as considerable nitrogenous matter, making a very valuable food for man and animals.

The culture of the crop has been tried for some years in Florida, but, owing to the fact that the plants had to be propagated from cuttings, which were difficult to produce in a healthy condition, the yield of good plants per acre has been so small as to make the industry unprofitable. The difficulty of propagating from canes led the Department of Agriculture to experiment in the production of a strain of cassava that could be propagated from seeds sown annually. Most of the varieties do not come true to seed, and the results are so variable when the seed is planted that heretofore it has not been adopted as a method of propagation. The department has, however, as a result of several years' selection secured strains which produce readily and uniformly from seed, yielding from 8 to 10 tons of roots per acre. It is believed that the use of these new varieties will make this one of the most important root crops of Florida and possibly of other areas along the Gulf coast. It is valuable not only for stock and as tapioca, for human food, but for starch, glucose, and alcohol manufacture. It is believed that as a source of denatured alcohol it will be cheaper than any other starch-producing plant.

VEGETABLES.

It will not be possible in this paper to discuss individually the very great number of crops grown as vegetables for market. Market gardening in the neighborhood of the large cities has developed at a rapid rate in the past ten years. Over 2,000,000 acres are reported in the last census as having been devoted to vegetable crops on over 615,000 farms. Twenty-five per cent of these farms derive their principal income from vegetables. These crops are produced in the neighborhood of the large markets under very intensive culture, the most careful attention being given to every detail of cultivation, both in the matter of the selection of soils, their fertilization, the selection of seed, and the marketing of the crops. With the increased facilities in transportation, and the great growth of the canning industry, the areas available for market gardening and truck crop growing have been greatly increased in recent years.

FRUITS.

Next to vegetables and flowers and products under glass, the most careful attention has been given in the United States to the production of fruits. According to the last census, the total production for the United States amounted to over $131,423,000. Of this, $83,751,040 represented orchard fruits, a little over $14,000,000 grapes, over $25,000,000 small fruits, and about $8,500,000 subtropical fruits.

Orchard fruits.—Of the orchard fruits, 55 per cent was apples, 27.2 per cent peaches and nectarines, 4.8 per cent pears, 8.4 per cent plums and prunes, 3.2 per cent cherries, and 1.4 per cent apricots. According to the census reports, the apple increased its proportion of the total production of orchard fruits from 76.3 per cent in 1889 to 82.8 per cent in 1899; the pear from 1.6 per cent to 3.1 per cent; the plum from 1.4 to 4.1 per cent; cherries, 0.8 to 1.4 per cent; apricots, 0.5 to 1.3 per cent. Peaches, owing to a complete failure in many sections, decreased from 19.4 per cent to 7.3 per cent. The States which took the lead in 1899 in the value of their orchard products were: California, over $14,500,000; New York, over $10,500,000; Pennsylvania, nearly $8,000,000; Ohio, over $6,000,000; Illinois, nearly $4,000,000; Michigan, nearly $4,000,000; Indiana, over $3,000,000; Missouri, nearly $3,000,000; Virginia, over $2,500,000; New Jersey, over $2,500,000.

These States reported an aggregate value of orchard fruits of over $58,000,000, or 69.3 per cent of the total value of all orchard fruits in the country.

There is an immense number of varieties of all these fruits grown in the United States, some of them introduced from foreign countries and others produced as chance seedlings from time to time here. Our finest apples have largely been the result of seedlings discovered from time to time by different growers. In the early days of the country, before the development of nurseries, many of the orchard trees were raised from seed, and most of our valuable varieties originated during this period of seedling orchards. Later, with the development of nurseries and the bud propagation of the more valuable sorts, the development of seedling varieties gradually dropped into the background. In recent years, however, as the demand for better acclimatized sorts has developed, more attention has been given to the production of seedlings. This is especially true in the northern Mississippi Valley region, where the very cold winters and hot dry summers are very destructive to the tenderer orchard fruits.

A number of serious disease and insect pests attack all our orchard fruits, in the case of the apple and pear especially the bacterial blight and the codling moth. The bacterial blight is very difficult to control and has destroyed the finer varieties of pear in most parts of the United States. Until recently the great Bartlett pear orchards of California were comparatively free from this disease, but within the past few years it has been introduced and has destroyed more than $5,000,000 worth of orchards, representing about one-third of the pear industry of that region. Methods for controlling the disease have been worked out, but they are not yet entirely satisfactory.

The various leaf diseases and the diseases attacking the fruit can be controlled by spraying, and progressive orchardists now follow this practice.

Peaches.—In the case of peaches the principal disease in California is a twig and limb blight, which practically destroyed the industry in many sections until the Department of Agriculture demonstrated that the disease could be controlled by spraying with Bordeaux mixture. In the Eastern and Southern States the principal disease of the peach is the yellows. In Michigan and New York a new disease known as "little peach" has appeared, and in all these sections, especially in the South, peach rot, caused by a fungus attacking the fruit, is very destructive. The first two diseases can be controlled by the eradication method; that is, the immediate destruction of the diseased trees and replanting. The latter disease heretofore has not been controllable, owing to the fact that the copper-spraying mixtures have been destructive to peach foliage. The recent discovery by one of the department experts that the peach rots could be controlled by self-boiled lime-sulphur mixture has marked the beginning of a new era in peach culture.

One of the principal difficulties with our cultivated varieties of peaches is probably that they are not perfectly adapted to the climatic conditions of our Eastern and Southern States. Whether improvements can be made along the line of better adaptation of varieties is still a question so far as peaches are concerned. A southwestern species closely related to the cultivated peach may possibly be of some value in this connection.

Plums.—The blood of our native plums has largely entered into the varieties adapted for culture in the various sections of the United States. The European plums and even the Japanese varieties have not proved to be well adapted to our climatic conditions and are not resistant to the diseases and insects prevalent here. Hybrids between many of these finer-fruited sorts and our native plums, however, combine the good qualities of both. There are over 200 horticultural varieties of native plums now described. While they are now largely cultivated, it is probable that the better hybrid sorts will eventually take their place.

Apples.—The apple, which appears to be fairly well adapted to our Northeastern States, is not well adapted to the severe climatic conditions of the upper Mississippi and Missouri valleys. Some seedling varieties have been developed which are superior to the ordinary cultivated sorts, but the final development of varieties adapted to this region of extremes of climate will undoubtedly come through the introduction of the blood of the native crab of that region. If the resistance, vigor, and adaptability of this native species can be combined with the good fruit qualities of the ordinary apple, an ideal variety will be produced.

Small fruits.—The total acreage of small fruits reported in the last census was 304,029 acres, valued at $25,030,877, and may fairly represent the status of this class of crops. From the commercial standpoint, the small fruits are usually classed with vegetables and truck crops and are cultivated for special markets or for canning and drying. The small amounts usually grown on most farms and often on city lots for home use are usually not reported for census enumeration, but in the aggregate amount possibly to as much as the reported area.

The small fruits of greatest importance are the strawberries, raspberries, blackberries, currants, gooseberries, and cranberries. There are a very large number of excellent varieties of all these fruits, developed largely from our native wild species. Introduced varieties were early found not to be well adapted to our conditions and were seriously affected by diseases occurring on our wild species, but to which our native species were resistant. However, in the improvement of varieties our native and introduced species have often been hybridized and the good qualities of both sorts thus combined. The strawberry, our most important small fruit, is an exception to this rule, as the species giving rise to our cultivated strains is a native of Chile, although there are a large number of good native varieties. In all the small fruits, however, there is the greatest opportunity for improvement, especially along the line of adaptation to special conditions and uses. With the increasing demands for this class of fruits improvements are gradually taking place. We have the foundation of our native species for almost unlimited development.

Grapes.—With the exception of California, the grape industry of the United States is based on our native species, the improved varieties being largely accidental seedlings. The Old Cape or Alexander grape was found wild in the woods of Pennsylvania; the Catawba was found in the woods of South Carolina; the Concord was a chance seedling in a Massachusetts garden, probably from the wild fox grape; the Worden was raised from a seed of Concord; the Delaware was probably a chance cross between a native species and a European variety, as both existed where the Delaware originated. Some very fine varieties, like the Brighton, were the result of artificial crosses. Only a very little has been done in the production of varieties for special purposes and in their general improvement. The quality of

European grapes is far superior to that of the American varieties, but the former are not adapted to our climate or resistant to our grape diseases, especially the phylloxera and black and brown rots. If the vigor and disease resistance of our native species can be bred into some of the finer European sorts, it would mean a new era for the grape culture of the Southern, Eastern, and Middle States.

In California the European varieties do fairly well, and a large industry in their culture has developed. Many of the varieties, however, are not perfectly adapted to California conditions, and the introduction of some American vigor has already been found necessary in order to obtain resistance to phylloxera, which has now gained a foothold in California, and to the California vine disease, which is very destructive to the tender European sorts.

California has over 90,500,000 vines, producing over 721,000,000 pounds of grapes, valued at over $5,500,000. These are largely of the European types. New York has over 29,500,000 vines, producing nearly 250,000,000 pounds of fruit, valued at nearly $3,000,000. Ohio has about half as much as New York, and Pennsylvania, Michigan, Illinois, Indiana, Kansas, Missouri, Georgia, Iowa, and Oklahoma have from 3,000.000 to 5,000,000 vines each.

There is a decided tendency to the overproduction of the American varieties. Even in the culture of the more resistant strains careful spraying is necessary in order to control the black and brown rots.

Subtropical fruits.—Of the subtropical fruits the principal ones are the orange, lemon, banana, pineapple, lime, citron, pomelo, guava, olive, etc. Of these the largest industry is in orange culture, California leading with about 5,500,000 trees, Florida with 2,500,000, Louisiana with 141,116, Arizona with 48,570, and smaller numbers in Texas, Mississippi, Alabama, and a few other States.

The principal lemon industry is in California, Florida, Arizona, and to a small extent in other States. The other citrus fruits are also grown in the same States.

The principal difficulty with the citrus industry arises from the effect of cold waves and heavy frosts striking the orchards during the growing season. The industry has been several times nearly destroyed in Florida and the Gulf States from this cause and has suffered seriously in some localities in California. Most of the citrus fruits cultivated in the United States are the results of what might be considered chance introductions and chance seedlings. There are many much more cold-resistant varieties of oranges in India, China, and Japan, which would doubtless prove valuable for northern Florida and the Gulf States. These introductions will be made by the Department of Agriculture. Another recourse is the crossing of the tenderer fine-fruited sorts with the cold-resistant *Citrus trifoliata*, which grows as far north as Philadelphia. From the many results of such crosses it is evident that oranges of much greater cold-resisting power can be developed. A large number of new types of citrus fruits have thus been secured, some of which are seedless and very juicy, some very sour, some moderately sour, and some fairly sweet. These are of first generation hybrids, however, and it is from the second generation that the larger number of intermediate sorts will develop. Varieties of citrus fruits for home use will undoubtedly result from such breeding work adapted for growth throughout the cotton States and the Southwest.

In the hotter sections of the Southwest where irrigation is practiced there are many areas of soil too alkaline for ordinary crops which are adapted to the date palm. About 50 varieties of the finer strains of dates have been introduced from the Old World and are found to give excellent results in this southwestern region. A profitable fruit industry can therefore be built up in soils and climate not adapted to other fruits. In the drier sections of the Southwest the dry-land olive is proving successful, and this valuable source of olive oil can undoubtedly be cultivated over large areas in Arizona and California, and possibly in New Mexico.

The pistache nut, also adapted to these dry areas, has been introduced and is proving well adapted to the region.

Similar improvements have been undertaken with the lime, the lemon, the grape fruit, the tangerine, and other species. In the case of the pineapple more than 200 new seedling varieties have been developed, some of which are far superior to any varieties now grown in the United States.

Besides these fruits there are many other tropical and subtropical fruits which are being tested in these regions and can be developed into industries of considerable importance as soon as there is demand for them.

NUTS.

Almonds.—The cultivation of almonds has developed to a considerable extent in California and Arizona, principally, however, in the former State, where over 1,500,000 trees are grown, producing nearly 7,000,000 pounds of nuts.

Cocoanuts.—Cocoanuts are produced in considerable numbers in Florida, approximately 50,000 trees being recorded in that State in the last census. This nut, however, is far more important in Cuba, Porto Rico, and the Philippines. It has recently been attacked by a serious disease, destroying in a short time many of the trees. Unless some means of control is discovered it is feared that the industry will be destroyed in all these places. The disease has not yet reached Florida or Porto Rico.

Pecans.—The pecan hickory is native in the Southern Central States, and many valuable seedling varieties are known. The nut has been planted in orchards in recent years and large quantities are thus produced. The finer varieties are now being selected and propagated by budding and grafting, so that the nut can now be said to be practically domesticated and in the process of improvement. Something over 3,000,000 pounds were produced during the last census year, about 56 per cent of which was grown in Texas. The pecan is susceptible of great improvement, and the extension of this nut industry is certain to be very great, provided the diseases which attack the cultivated orchards can be controlled.

English walnuts.—The Persian or English walnuts are cultivated to a considerable extent in southern California, where there are now nearly a million trees, producing something over 10,000,000 pounds of nuts. Not much attention has been given to varieties, so that the orchards are considerably mixed. A serious disease caused by bacteria has greatly reduced the yield, but it has been discovered that certain varieties are resistant, and it is probable that many of the orchards will be worked over to these resistant strains.

Very little attention has been given to the improvement of the great number of native nuts growing in various sections of the United States. With the increasing importance of this class of fruits it is probable that the native species will be domesticated and greatly improved in the near future.

SUMMARY.

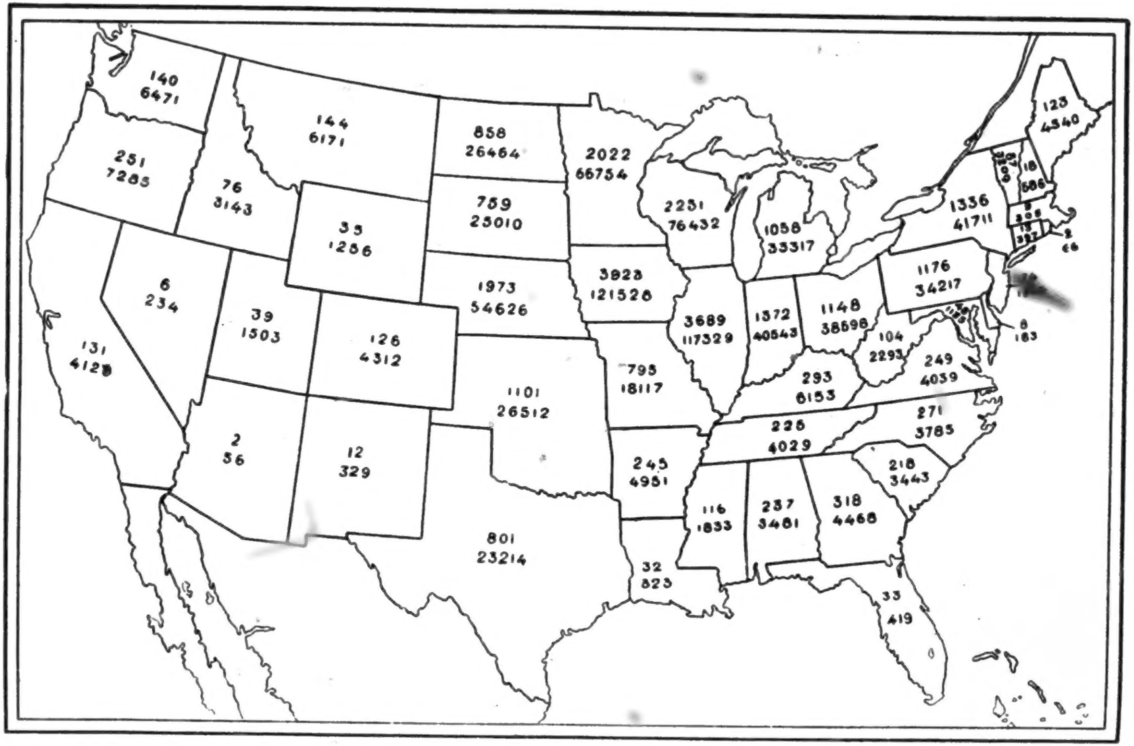
I have now presented very briefly some of the principal facts regarding our important cultivated and native plants, and have shown that we have in all our plant resources a large number of extremely valuable varieties and sorts of local adaptation simply waiting to be utilized. Our agriculture and horticulture have been extremely primitive in the attention which has been given to seed selection, the improvement of varieties, and their adaptation to special uses. This, of course, has been the result of the rapidly expanding areas brought under cultivation and the general promiscuous and careless testing of varieties. In the past the great market demands for staple crops have given little consideration to anything but the most general qualities. Improved transportation methods have brought practically the whole world into competition, so that the cheapest and most extensive methods have necessarily prevailed. As population increases and territorial expansion decreases, the demand for more intensive methods becomes greater and more attention can be given to the improvement of cultural methods. The first step in this direction will certainly be the better utilization of our enormous plant resources.

It has been shown that by careful selection of the best individual plants, and propagating from these, the yield of all our important staple crops could easily be doubled. The means for accomplishing this already exist in our fields and gardens. For still greater improvement we can draw on cultivated and wild plants throughout the world. With the exception of the absolutely arid sections of the United States, where no rainfall or other source of water is available, there is not a foot of ground from which valuable crops can not be secured or developed, and these include grain, forage, and fruits.

Besides the great gains which can be secured by the selection and improvement of varieties of crops, the improvements in cultural methods also offer opportunities for great increase in quantity, quality, and certainty of yield. The great mass of our farmers have been as careless in their methods of agricultural production as they have in their selection of varieties. While there has been tremendous waste in following such methods, due to the rapid expansion, the close competition, and the small margin of profit, the conditions have nevertheless been the cause of the development of some of our most important mechanical methods. It has been necessary to cultivate large areas with a small amount of labor, which has led to the wonderful development of mechanical methods and improved machinery which has characterized American agriculture.

Along with the general careless methods, little attention has been given as a rule to the conservation of soil fertility. This matter has been referred to briefly in the discussion of the various crops and will not be entered into further in this paper, as it is covered by the work of another bureau. Although the larger part of the product of plant growth is taken directly or indirectly from the air, nevertheless a small but essential part comes from the soil, and it is absolutely necessary, in order to maintain the soil in a highly productive condition, to keep in it a readily available supply of the essential nutrients, especially nitrogen, phosphoric acid, and potash. The physical condition of the soil, its water-holding capacity, and its ability to absorb oxygen are controlled in a large measure by the organic matter which it contains. A high humus content is essential to a good soil. More than any other factor influencing the fertility and crop-producing power is the organic life of the soil, especially the bacteria and fungi and low organisms of this class inhabiting it. The control of the nature and quantity of these organisms present is soon to become one of the most important factors in agricultural production.

The accumulation in the soil of organisms deleterious to crop growth, resulting from continued culture to a single crop, is one of the most prolific causes of the deterioration in crop-producing power, as has been pointed out in the case of a number of our most important crops. Besides the development of resistant crops, the most important procedure will be in the adoption of crop-rotation systems which prevent the accumulation of these parasites and which enable the producer to make the proper return to the soil, by fertilization and other means, of some of the elements taken from it.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6
234
39
1503
126
4312
1973
54626
3928
121528
2251
76432
1058
33317
1101
26512
795
18117
3689
117329
1372
40543
1148
38698
2
56
12
329
801
23214
245
4951
32
823
116
1833
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3481
318
4468
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419
293
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3785
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3443
104
2293
249
4039
1176
34217
8
183
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123
4340
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2800
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686
9
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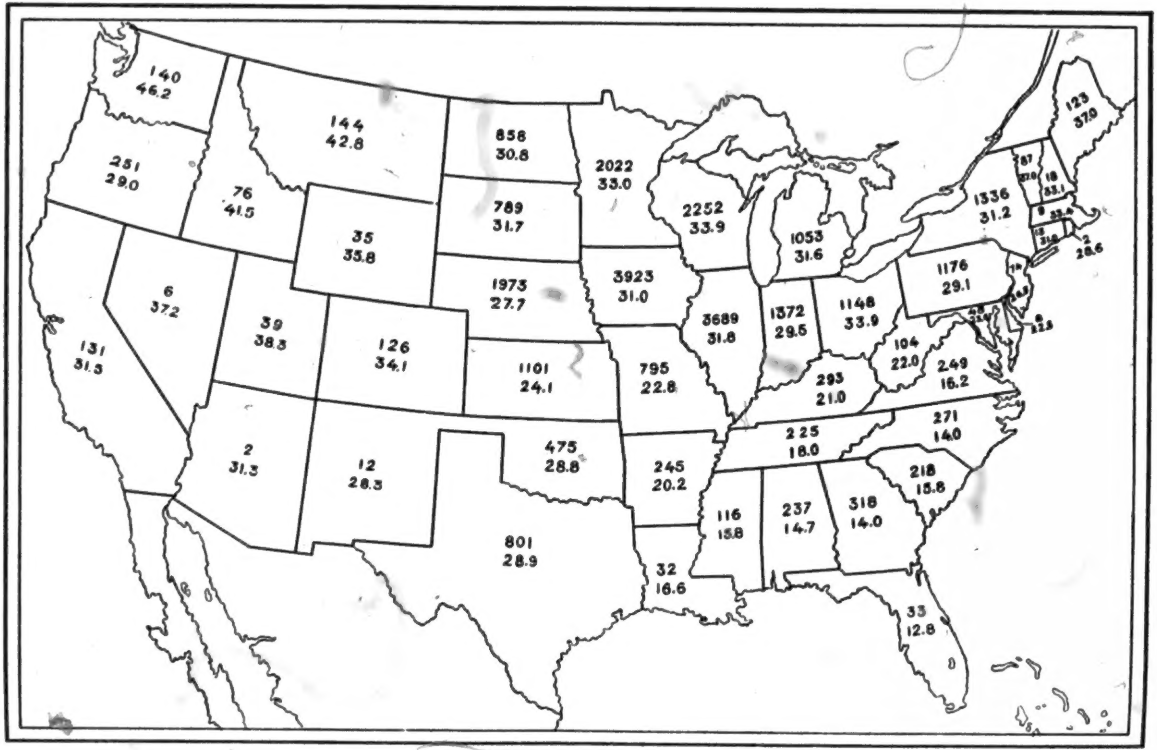
66

MAP NO. 1.—OAT CROP OF THE UNITED STATES, 1898–1907.

Upper figures show average annual acreage in thousands of acres. Lower figures show average annual production in thousands of bushels.



140
46.2
251
29.0
131
31.5
76
41.5
6
37.2
144
42.8
35
35.8
39
38.5
2
31.3
126
34.1
12
28.3
858
30.8
789
31.7
1973
27.7
1101
24.1
475
28.8
801
28.9
2022
33.0
3923
31.0
795
22.8
245
20.2
32
16.6
2252
33.9
3689
31.8
1053
31.6
1372
29.5
1148
33.9
293
21.0
225
18.0
116
15.8
237
14.7
318
14.0
33
12.8
218
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271
14.0
104
22.0
249
16.2
1176
29.1
1336
31.2
87
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18
33.1
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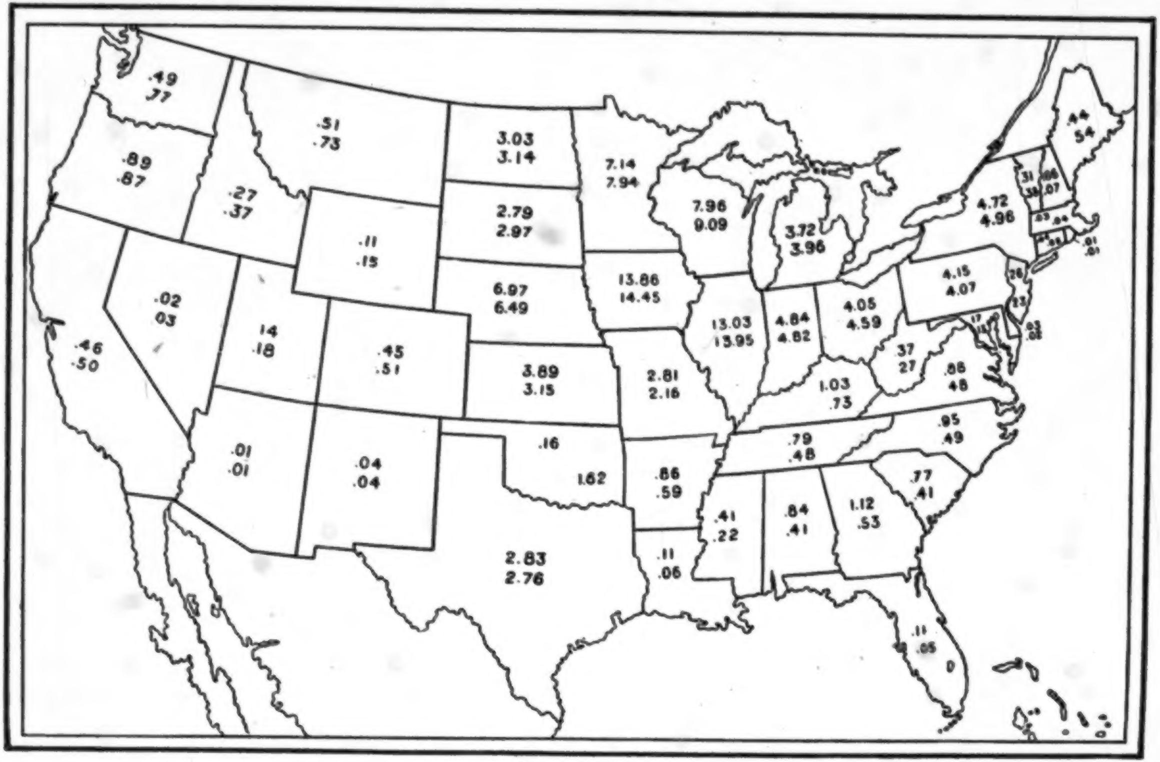
8
123
37.0

MAP NO. 2.—OAT CROP OF THE UNITED STATES, 1898-1907.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03
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.01
.45
.51
.04
.04
3.03
3.14
2.79
2.97
6.97
6.49
3.89
3.15
.16
1.62
2.83
2.76
7.14
7.94
13.86
14.45
2.81
2.16
.86
.59
.11
.06
7.96
9.09
13.03
13.95
.41
.22
3.72
3.96
4.84
4.82
.84
.41
4.05
4.59
1.03
.73
.79
.48
1.12
.53
.11
.05
0
37
27
.88
48
.95
.49
.77
.41
4.15
4.07
4.72
4.96
31
38
.06
.07
.44
54
.03
.04
.01
.01
26
23
17
15
.03
.03

MAP NO. 3.—OAT CROP OF THE UNITED STATES, 1898-1907.

Upper figures show percentage of average annual acreage. Lower figures show percentage of average annual production.

THE OAT CROP.

By C. W. WARBURTON,

Bureau of Plant Industry, United States Department of Agriculture.

IMPORTANCE OF THE CROP.

Oats rank fifth among the farm crops of the United States in importance and value, being exceeded only by corn, hay, cotton, and wheat. The average area devoted to the production of this crop in the ten years from 1898 to 1907 has been 28,300,000 acres, while the average annual production has amounted to 841,000,000 bushels. The average annual farm value for the same period, as estimated by the Bureau of Statistics of this department, has been $265,596,000, or $9.38 to the acre. This is slightly less than the acre value of the wheat crop, $9.62, and about a dollar less than that of corn, $10.40.

The accompanying map (No. 1) shows the average annual acreage in each State for the past ten years and the average total production of each State. Map No. 2 also shows the annual acreage, with the average yield to the acre, while map No. 3 shows each State's proportion of the annual acreage and production. This last is of particular interest, as it shows the relation between acreage and production in the various States. Thus Iowa, the leading State, produces 14.45 per cent of the total crop on 13.86 per cent of the acreage, and Illinois produces nearly 14 per cent of the crop on slightly more than 13 per cent of the acreage. As extremes, Washington and Georgia may be cited, the latter producing but 0.53 per cent of the total crop on 1.12 per cent of the acreage, while the former shows 0.77 per cent on but 0.49 per cent of the total area.

REGION OF GREATEST PRODUCTION.

The production of oats is greatest in the northern Mississippi Valley, in the northern part of the region generally known as the corn belt, and in the States lying just to the north of that belt. The "oat belt" might be said to include Iowa, Illinois, Wisconsin, Minnesota, North Dakota, South Dakota, and Nebraska. In these 7 States are included 54.78 per cent of the total acreage and 58.03 per cent of the production. If the crop of Michigan, Ohio, and Indiana is added to that of the 7 States just mentioned, these figures increase relatively to 67.91 per cent and 71.4 per cent. While the crop is thus centralized it is comparatively cosmopolitan in its nature, for it is grown in every State and Territory, and in only two, Rhode Island and Arizona, is the annual crop less than 100,000 bushels, while corn falls below that figure in Montana, Wyoming, and Nevada. In 15 States, notably in New York, Wisconsin, and Minnesota, the oat crop exceeds the corn crop in value.

NEED FOR IMPROVEMENT.

While the foregoing figures show that the oat crop is very largely to be reckoned with in our farm economy, yet the partial failures in the two seasons just past, 1907 and 1908, in which unfavorable weather conditions, insects, and diseases combined to reduce the production to a point well below the ten-year average, indicate the need of a thorough study of varieties and their adaptation, methods of combating insect and fungous pests, and of seeding, fertilizing, and harvesting the crop.

VARIETAL ZONES.

No very definite divisons can be made to show the adaptability of varieties or of classes of varieties, but, roughly speaking, the States may be grouped into three zones, the southern one including Delaware, Maryland, West Virginia, Kentucky, Missouri, Kansas, and the States to the south, and extending westward through New Mexico and Arizona to California; a central belt including New Jersey, Pennsylvania, Ohio, Indiana, Illinois, Iowa, and Nebraska; and a northern one embracing New England, New York, Michigan, Wisconsin, Minnesota, the Dakotas, the Intermountain States, and the States of the Pacific Northwest. This division is inaccurate and far from satisfactory, but in general the best producing varieties or types are similar within these three divisions.

THE SOUTHERN DIVISION.

The first, or southern, division includes about 20 per cent of the total annual acreage of oats, but produces only 15 per cent of the crop. The varieties most largely grown are Rustproof, Virginia Gray, and Burt. Rustproof, often called "Texas Red" or "Texas Rustproof," is the typical and parent variety of the Rustproof group, which includes Appler, Lawson, and Culberson. This group, as usually grown, is a mixture in varying proportions of at least three varieties, the typical large-grained red oat of the true Rustproof variety, a strain with medium-sized black grains, and one with small white ones. It is probable that the red grain is the most desirable type, though very good results have been secured from the small white strain when separated from the mixture. The ordinary red type is of medium height, straw usually strong, and the grain large and reddish or yellowish brown in color. Practically all of the berries are bearded, the beards, particularly on the larger grain, being large and long. The larger grain is also provided with a number of long, bristly hairs at the base, a characteristic which distinguishes this group from the other varieties commonly grown in the South, in which the bristles are either entirely wanting, occur on only a few of the spikelets, or are much shorter than on Rustproof. The varieties of this group are, as the name indicates, resistant to rust, and are generally the most productive and satisfactory for growing in the section under discussion. They may be sown in the South either in fall or spring—in fact, at any time from September to March. In the northern part of the belt, late winter or spring sowing is generally advisable, though the fall-sown crop is usually more productive when it survives the winter.

Virginia Gray or Winter Turf is a taller, more slender variety than Rustproof, adapted to fall or early winter sowing in this region. It is rather hardier than Rustproof and is grown largely in Virginia and North Carolina, and to some extent in Kentucky, Tennessee, and the other Southern States. It is not usually successful when sown in the spring. The grain is of medium size, usually not bearded, gray or light grayish yellow. The two grains of the spikelet separate readily in thrashing, while in Rustproof they are usually quite persistent. This variety is of value where Rustproof will not withstand the winter, or where the production of hay or straw is more important than that of grain.

Burt is the only strictly spring variety of oats generally grown in the South. At present it can hardly be considered of importance outside of Kentucky and Tennessee, though it is grown to some extent in the higher portions of the other Southeastern States. This variety, sometimes known as "Ninety-Day" or "May," has more slender, lighter-colored grains than Rustproof, and the spikelets are usually without the basal hairs. It ripens earlier than Rustproof and in some sections is more productive. On account of its earliness it frequently escapes injury from fungous diseases which attack other spring-sown varieties. This variety, as well as Virginia Gray, is quite pure as ordinarily grown.

The greatest need for work on oats in the South, so far as the variety question is concerned, is the production of pure strains of Rustproof, which are winter hardy and highly productive. This should be comparatively easy to accomplish in a few years by careful selection. Other means of increasing the acre yield, and so increasing the net return, are good preparation of the seed bed, fertilization, and early seeding.

The oat crop in the South is frequently put in with little preparation, the seed sometimes being sown broadcast on cornstalk or other land and covered with a cultivator or disk harrow. Where a grain drill is available, however, it is more frequently used than is the case in the corn belt. Sowing with a grain drill not only aids in securing a uniform stand by distributing the seed evenly and covering it all to the same depth, but, in the case of fall-sown grain, the furrows left by the drill serve as a protection from the heaving caused by the alternate freezing and thawing of winter and early spring. In some sections of the South, particularly in Georgia, what is known as the "open-furrow" method of seeding is quite common. A planter similar to a cotton planter is used, the seed being drilled in the bottom of an open furrow. This furrow is left open through the winter, except as it is closed naturally by the washing of the banks and by the action of frost. This method obviates in a large measure the danger of winter damage, but is slow and expensive, as only one row can be sown at a time. A machine on the order of a grain drill, which sows several rows at once but leaves the ground more ridged than the ordinary type of that tool, is desirable for the winter oat region.

In the South, as in the North, the oat crop is ordinarily grown on the poorest land. While it is true that oats will produce relatively more on poor land than will other grain crops, yet the crop responds so readily to good treatment and fertilizers that the extra expense is justified. The use of fresh manure is not advisable as it is likely to cause a rank growth of straw, liable to lodge, at the expense of grain production. Well-rolled manure and complete fertilizers, particularly those rich in potash and phosphorus, are productive of the best results, though nitrogenous fertilizers, especially those in the form of green manures, are decidedly beneficial.

The winter oat crop is ordinarily sown in late October or November, whereas careful tests show that larger and more certain crops can be secured by seeding in September or early October. If spring seeding is necessary, it should be done as early as possible—during February in the extreme south and in March in the northern part of this belt. Spring seeding is not to be recommended, however, where there is any possibility of securing a stand from fall sowing.

The advantage of early fall seeding over later sowing is obvious. The young plants become well established before cold weather, and the growth of both top and root is often sufficient to prevent winter injury which would be serious in the late sown fields. Fall or very early spring seeding is to be recommended over late spring seeding, as it hastens maturity, i. e., the crop ripens in time to avoid much damage from unfavorable weather conditions and fungous diseases.

THE CENTRAL DIVISION.

In the central belt, which includes 47 per cent of the crop area and 48.5 per cent of the total production, oats, while largely grown, can not be considered profitable. A recent estimate by Prof. A. N. Hume, of the Illinois Experiment Station, shows that the average crop of oats in that State, 33 bushels, is produced at a loss of $3.32 per acre. However, the oat crop is a very necessary one in the common systems of rotation used in the corn belt, and is not to be discarded on the showing just quoted. Then, too, the best farmers secure yields much better than the state average, and the price, at least in recent years, is considerably higher than the 26 cents per bushel used in this calculation.

The varieties of oats grown in the central belt are too numerous for extended mention, but may be roughly divided into the small, early, yellow varieties, with rather light, slender straw, small, slender, white or yellow grain, maturing in ninety to one hundred days from sowing, and the large, medium to late varieties, taller and more rank growing with medium to large, usually white grain, maturing in one hundred to one hundred and twenty days. The latter group may be further divided into the Potato and Welcome groups, the former with short, plump grains, and the latter with longer, more pointed ones. In the first class may be included Alaska, Early Champion, Sixty-Day, and Kherson, the two latter having been imported from southern Russia about ten years ago. In the Welcome group may be included such well-known varieties as American Banner, Clydesdale, Lincoln, Silvermine, and Welcome, while in the Potato group Early Siberian, Green Mountain, Probsteier, White Schoenen, and Wideawake are to be found. The first-named group, though perhaps occupying the smallest acreage, is probably the most reliable, on account of its earliness, which enables it to escape unfavorable weather conditions and resultant attacks of fungous diseases. The chief objections to the varieties of this class are the small size of the grains and, in the case of Sixty-Day and Kherson, the yellow color. In tests at the Illinois, Iowa, and Nebraska stations, however, these two varieties have in recent years been most reliable. Early Champion is specially liable to smut attacks, and should always be treated with some one of the well-known smut preventives.

Of the Welcome group, Silvermine is perhaps the best known and most widely popular variety. The varieties of this group, however, frequently mature too late for the best results, as when sown around April 1, their ripening period, during the first two weeks of July and extending up to July 20 in the northern portion of this belt, is frequently decidedly unfavorable for the development of the oat crop. The oat crop is usually most satisfactory in cool, moist climates, and the heat of the July days in the corn belt is often disastrous, whether the weather is wet or dry. In a dry season, the grain ripens prematurely and is shriveled and light, and in a wet one, rust develops rapidly, with its resultant serious effect on the grain yield. The use of early varieties, which frequently mature before the weather conditions become unfavorable, is strongly to be recommended in the corn belt.

In the matter of soil preparation, the oat crop gets little attention. A circular of inquiry sent out to Iowa farmers showed that practically the entire oat crop was sown on corn ground, and more than 70 per cent of the farmers gave no previous preparation. The usual method is to sow the grain broadcast, then disk and harrow. In this manner it is put in at varying depths, germination extends over a considerable period, and the early growth of the crop is irregular. A considerable portion of the seed is covered so little or so much that it fails to germinate at all. Double disking and double harrowing of cornstalk land before seeding is strongly to be recommended, and sowing with a grain drill at a depth of 2 inches is desirable. In a test at the Iowa station, drilled seed yielded nearly 10 bushels more to the acre than broadcasted seed in 1907, a season of poor oat crops in that section.

Few fertilizer experiments with oats have been conducted in this section. The general belief that it is advisable to apply manure immediately preceding an oat crop is well founded, and the practice of manuring for corn and following the corn with oats is no doubt the best plan which can be devised. However, it may be well to apply some form of potash to the oat crop, for corn-belt soils are often low in available forms of this element and its addition might go far to solve the problem of weak straw and lodging.

THE NORTHERN DIVISION.

In the northern belt, where 33 per cent of the total oat acreage of the United States produced 36.5 per cent of the crop, the varieties ordinarily grown are of the same late maturing type frequently found in the section just discussed, though occasionally varieties of the early type are grown. In some sections "side" oats are the prevailing type. The varieties of this type are even later than the Potato oats. Owing to the fact that conditions here are usually more favorable during July than they are in the corn belt, late varieties are more reliable, though in some seasons they are not productive. At the Wisconsin station, Sixty-Day, a variety of the early type, and

Swedish Select, a Potato oat, are the highest yielding varieties. At the Minnesota station the leading varieties are Early Gothland, a rather early variety of the Silvermine type, and Imp. Ligowo, of the Potato type, while in South Dakota Sixty-Day and Swedish Select are prominent. In North Dakota side oats of the White Russian and Tartarian varieties are largely grown, though Sixty-Day has been a very satisfactory variety at the experiment station. In Montana and the Pacific Northwest the prevailing varieties are the late maturing Potato and side types.

General discussion of soil preparation, methods of seeding, and fertilization in the central district is also applicable here, though the more favorable weather conditions and better adapted varieties make the oat crop more commonly profitable than in the corn belt. Indeed, the oat crop is second only to wheat in this region and in some of the States is of even greater value than that grain.

The need of rotation and of cultivated crops is particularly great in some sections of this belt. In portions of Minnesota, and throughout the Dakotas and the Northwestern States, continuous cropping to wheat, barley, flax, and oats has greatly decreased the fertility of the land and increased the growth of weeds. An increased proportion of grass land and cultivated crops will check the weed nuisance, and the fertility of the land may be restored by the use of clover and other green-manuring crops, and of manure. More live stock should be kept, and the acreage of small grain should be reduced. With proper handling 3 acres will produce as much wheat or oats as 4 do now, and the remaining one-fourth of the land may be devoted to forage and live stock without reducing the grain production.

SMUT TREATMENT.

It is probable that smut annually destroys from 3 to 5 per cent of the oat crop of the United States. In certain sections, and in years favorable to smut development, the loss is much greater. A conservative estimate of 4 per cent of the annual crop would mean a loss of 34,000,000 bushels on an average crop, or a money loss on the same basis of more than $10,000,000. In view of the ease and cheapness of preventive treatment, either with formalin solution or hot water, there is no reason why this annual loss could not be almost entirely avoided.

METHODS OF HARVESTING.

While the discussion thus far has been entirely concerned with the preparation of the soil and the sowing of the crop, there is need of more attention in many sections to the methods of harvesting, particularly with regard to stacking the grain.

When properly handled the grain goes through three "sweats" or ripening processes, each of which, under suitable conditions, improves the quality. The first is in the shock, the second in the stack, and the third in the bin after thrashing. The very common practice of thrashing from the shock, a practice seemingly increasing in vogue, does away with the second sweat, and at the same time greatly increases the possibility of deterioration in quality from weather damage. The increase of cost from stacking is usually much more than balanced by the increased value of the crop over that left in the shock until thrashed.

SUMMARY.

The oat crop, which ranks fifth in importance among our farm crops, is annually valued at about $265,000,000. More than one-half of the entire crop is produced in seven States in the upper Mississippi Valley.

While immensely valuable and a very necessary crop in rotations, oats are frequently produced at a very small profit or often at a loss.

There is great need of improvement in varieties, methods of soil preparation, seeding, and harvesting to obviate this loss.

The United States can be approximately divided into three varietal zones.

The typical varieties of the southern zone are Rustproof, Virginia Gray, and Dun. The crop can be increased in the South by the selection of high producing winter strains, particularly of Rustproof, by early seeding and by the liberal use of fertilizers.

The typical varieties of the central zone are Sixty-Day, Silvermine, and White Schoenen. In this section the use of the earliest varieties, better preparation of the soil, and drilling are suggested.

In the northern belt, the region of greatest production to the acre, Tartarian, Swedish Select, Progress, and Sixty-Day are typical varieties. Better yielding strains of these varieties, better preparation of the soil, and drilling will increase the yield. Preventive treatment is essential to prevent serious loss from smut. Stacking will ordinarily increase the quality of the grain, while thrashing from the shock greatly increases the possibility of injury from bad weather.

THE ORIGIN OF CULTIVATED PLANTS.

By Alphonse De Candolle.

SUMMARY AND CONCLUSION.

[The "Summary and Conclusion," Part III of "The Origin of Cultivated Plants," by Alphonse De Candolle, is here reprinted (with some slight modifications) for convenient reference in connection with the article entitled "Agricultural Production," by A. F. Woods.]

GENERAL TABLE OF SPECIES, WITH THEIR ORIGIN AND THE EPOCH OF THEIR EARLIEST CULTIVATION.

The following table includes a few species of which a detailed account has not been given, because their origin is well known and they are of little importance.

Explanation of the signs used in the table: (1) Annual; (2) biennial; 4, perennial; 5, small shrub; 6, shrub; 7, small tree; 8, tree. The letters indicate the certain or probable date of earliest cultivation. For the species of the Old World: A, a species cultivated for more than four thousand years (according to ancient historians, the monuments of ancient Egypt, Chinese works, and botanical and philological indications); B, cultivated for more than two thousand years (indicated in Theophrastus, found among lacustrine remains, or presenting various signs, such as possessing Hebrew or Sanskrit names); C, cultivated for less than two thousand years (mentioned by Dioscorides and not by Theophrastus, seen in the frescoes at Pompeii, introduced at a known date, etc.). For American species: D, cultivation very ancient in America (from its wide area and number of varieties); E, species cultivated before the discovery of America, without showing signs of a great antiquity of culture; F, species only cultivated since the discovery of America.

Species native to the Old World.

CULTIVATED FOR THE SUBTERRANEAN PARTS.

Name and duration.	Date.	Origin.
Radish—Raphanus sativus (1)	B.	Temperate Asia.[a]
Horse-radish—Cochlearia armoracia 4	C.	Eastern temperate Europe.
Turnip—Brassica rapa (2)	A.	Europe; western Siberia (2).
Rape—Brassica napus (2)	A.	Europe; western Siberia (?).
Carrot—Daucus carota (2)	B.	Europe; western temperate Asia (?).
Parsnip—Pastinaca sativa (2)	C.	Central and southern Europe.
Tuberous chervil—Chærophyllum bulbosum (2)	C.	Central Europe; Caucasus.
Skirret—Sium sisarum 4	C.	Altaic Siberia; northern Persia.
Madder—Rubia tinctorum 4	B.	Western temperate Asia; southeast of Europe.
Salsify—Tragopogon porrifolium (2)	C. (?)	Southeast of Europe; Algeria.
Scorzonera—Scorzonera hispanica	C.	Southwest of Europe; south of the Caucasus.
Rampion—Campanula rapunculus (2)	C.	Temperate and southern Europe.
Beet—Beta vulg. (2) 4 Vegetable	B.	Canaries; Mediterranean basin; western temperate Asia.
Root	B.	A result of cultivation.
Garlic—Allium sativum 4	B.	Desert of the Kirghis, in western temperate Asia.

[a] Doctor Bretschneider writes to me from Peking, December 22, 1882, that the species is mentioned in the Ryd, a work of the year 1100 B. C. I do not know if we must suppose the original habitat to be China or western Asia.

Species native to the Old World—Continued.

CULTIVATED FOR THE SUBTERRANEAN PARTS—Continued.

Name and duration.	Date.	Origin.
Onion—Allium cepa (2)	A.	Persia; Afghanistan; Beluchistan; Palestina(?).
Welsh onion—Allium fistulosum 4	C.	Siberia (from the land of the Kirghis of Baikal).
Shallot—Allium ascolonicum 4	C.	Modification of A. cepa (?) unknown to wild.
Rocambole—Allium scorodoprassum 4	C.	Temperate Europe.
Chives—Allium schaenoprasum 4	C. (?)	Temperate and northern Europe; Siberia, Khamschatka; North America (Lake Huron).
Taro—Colocasia antiquorum 4	B.	India; Malay Archipelago; Polynesia.
Apé—Alocasia macrorrhiza 4	(?)	Ceylon; Malay Archipelago; Polynesia.
Konjak—Amorphophallus konjak 4	(?)	Japan (?)
Yams—Dioscorea sativa 4	B. (?)	Southern Asia (especially Malabar) (?); Ceylon (?); (Java) (?).
Dioscorea Batatas 4	B. (?)	China (?)
Dioscorea japonica 4	(?)	Japan (?)
Dioscorea alata 4	(?)	East of the Asiatic Archipelago.

CULTIVATED FOR THE STEMS OR LEAVES.

1. VEGETABLES.

Cabbage—Brassica oleracea (1), (2), 5, 7	A.	Europe.
Chinese cabbage—Brassica chinensis (2)	(?)	China (?); Japan (?).
Water cress—Nasturtium officinale 4	(?)	Europe; northern Asia.
Garden cress—Lepidium sativum (1)	B.	Persia (?).
Sea kale—Crambe maritima 4	C.	Western temperate Europe.
Purslane—Portulaca oleracea (1)	A.	From the western Himalayas to southern Russia and Greece.
New Zealand spinach—Tetragonia expansa (1)	C.	New Zealand and New Holland.
Garden celery—Apium graveolens (2)	B.	Temperate and southern Europe; northern Africa; western Asia.
Chervil—Anthriscus cerefolium (1)	C.	Southeast of Russia; western temperate Asia.
Parsley—Petroselium sativum (2)	C.	Southern Europe; Algeria; Lebanon.
Alexanders—Smyrnium olus-atrum (2)	C.	Southern Europe; Algeria; western temperate Asia.
Corn salad—Valerianella olitoria (1)	C.	Sardinia, Sicily.
Cardoon	C.	Southern Europe; northern Africa; Canaries; Madeira.
Artichoke—Cyuara Cardunculus (2) 4 {Cardoon Artichoke.	C.	Derived from the cardoon.
Lettuce—Latuca scariola (1) (2)	B.	Southern Europe; northern Africa; western Asia.
Wild chicory—Cichorium Intybus 4	C.	Europe; northern Africa; western temperate Asia.
Endive—Cichorium Endivia (1)	C.	Mediterranean basin; Caucasus; Turkestan.
Spinach—Spinacia oleracea (1)	C.	Persia (?).
Orach—Atriplex hortensis (1)	C.	Northern Europe and Siberia.
Amaranth—Amarantus gangeticus (1)	(?)	Tropical Africa; India (?).
Sorrel—Rumex acetosa (1) 4	(?)	Europe; northern Asia; mountains of India.
Patience dock—Rumex patientia 4	(?)	Turkey in Europe; Persia.
Asparagus—Asparagus officinalis 4	B.	Europe; western temperate Asia.
Leek—Allium ampeloprasum 4	B.	Mediterranean basin.

2. FODDER.

Lucern—Medicago sativa 4	B.	Western temperate Asia.
Sainfoin—Onobrychis sativa 4	C.	Temperate Europe; south of the Caucasus.
French honeysuckle—Hedysarum coronarium 4	C.	Center and west of the Mediterranean basin.
Purple clover—Trifolium pratense 4	C.	Europe; Algeria; western temperate Asia.
Alsike clover—Trifolium hybridum (1)	C.	Temperate Europe.
Italian clover—Trifolium incarnatum (1)	C.	Southern Europe.
Egyptian clover—Trifolium alexandrinum (1)	C.	Syria; Anatolia.
Ervilia—Ervum Ervilia (1)	B.	Mediterranean basin.
Vetch—Vicia sativa (1)	B.	Europe; Algeria; south of the Caucasus.
Flat-podded pea—Lathyrus Cicera (1)	B.	From Spain and Algeria to Greece.
Chickling vetch—Lathyrus sativus (1)	B.	South of Caucasus.
Ochrus—Lathyrus ochrus (1)	B.	Italy; Spain.
Fenugreek—Trigonella fœnumgræcum (1)	B.	Northeast of India and western temperate Asia.
Bird's-foot—Ornithopus sativus (1)	B. (?)	Portugal; south of Spain; Algeria.
Nonsuch—Medicago lupulina (1) (2)	C.	Europe; north of Africa (?); temperate Asia.
Corn spurry—Spergula arvensis (1)	B. (?)	Europe.
Guinea grass—Panicum maximum 4	C. (?)	Tropical Africa.

Species native to the Old World—Continued.

CULTIVATED FOR THE STEMS OR LEAVES—Continued.

3. VARIOUS USES.

Name and duration.	Date.	Origin.
Tea—Thea sinensis 6	A.	Assam; China; Manchuria.
Flax anciently cultivated—Linum angustifolium 4 (2) (1).	A.	Mediterranean basin.
Flax now cultivated—Linum usitatissimum (1).	A. (?)	Western Asia (?); derived from the preceding (?).
Jute—Corchorus capsularis (1)	C. (?)	Java; Ceylon.
Jute—Corchorus olitorius (1)	C. (?)	Northwest of India; Ceylon.
Sumach—Rhus coriaria 6	C.	Mediterranean basin; western temperate Asia.
Khat—Celastrus edulis 6	(?)	Abyssinia; Arabia (?).
Indigo—Indigofera tinctoria 6	B.	India (?).
Silver indigo—Indigofera argentea 6	(?)	Abyssinia; Nubia; Kordofan; Sennaar; India (?).
Henna—Lawsonia alba 6	A.	Western tropical Asia; Nubia (?).
Blue gum—Eucalyptus globulus 8	C.	New Holland.
Cinnamon—Cinnamonum zeylanicum 7	C.	Ceylon; India.
China grass—Boehmeria nivea 4, 6	(?)	China; Japan.
Hemp—Cannabis sativa (1)	A.	Dahuria; Siberia.
White mulberry—Morus alba 7	A. (?)	India; Mongolia.
Black mulberry—Morus nigra 7	B. (?)	Armenia; northern Persia.
Sugar cane—Saccharum officinarum 7	B.	Cochin China (?); southwest of China.

CULTIVATED FOR THE FLOWERS OR THEIR ENVELOPES.

Name and duration.	Date.	Origin.
Clove—Carophyllus aromaticus 7	(?)	Moluccas.
Hop—Humulus lupulus 4	C.	Europe; western temperate Asia; Siberia.
Carthamine—Carthamus tinctorius (1)	A.	Arabia (?).
Saffron—Crocus sativus 4	A.	Southern Italy; Greece; Asia Minor.

CULTIVATED FOR THE FRUITS.

Name and duration.	Date.	Origin.
Shaddock—Citrus decumana 8	B.	Pacific Islands, to the east of Java.
Citron, lemon—Citrus medica 7	B.	India.
Bitter orange—Citrus aurantium bigardia 7	B.	East of India.
Sweet orange—Citrus aurantium sinense 7	C.	China and Cochin China.
Mandarin—Citrus nobilis 7	(?)	Do.
Mangosteen—Garcinia mangostana 7	(?)	Sunda Islands; Malay Peninsula.
Ochro—Hibiscus esculentus (1)	C.	Tropical Africa.
Vine—Vitis vivifera 6	A.	Western temperate Asia; Mediterranean basin.
Common jujube—Zizyphus vulgaris 6	B.	China.
Lotus jujube—Zizyphus lotus 6	(?)	Egypt to Morocco.
Indian jujube—Zizyphus jujuba 6	A. (?)	Burma; India.
Mango—Mangifera indica 6	A. (?)	India.
Tahiti apple—Spondias dulcis 6	(?)	Society, Friendly, and Fiji Isles.
Raspberry—Rubus idaeus 6	C.	Temperate Europe and Asia.
Strawberry—Fragaria vesca 6	C.	Temperate Europe and western Asia; east of North America.
Bird cherry—Prunus avium 8	B.	Western temperate Asia; temperate Europe.
Common cherry—Prunus cerasus 7	B.	From the Caspian to western Anatolia.
Plum—Prunus domestica 7	B.	Anatolia; south of the Caucasus; north of Persia.
Plum—Prunus insititia 6	(?)	Southern Europe; Armenia; south of the Caucasus; Talysch.
Apricot—Prunus Armeniaca 7	A.	China.
Almond—Amygdalus communis 7	A.	Mediterranean basin; western temperate Asia.
Peach—Amygdalus persica 7	A.	China.
Common pear—Pyrus communis 8	A.	Temperate Europe and Asia.
Chinese pear—Pyrus sinensis 7	(?)	Mongolia; Manchuria.
Apple—Pyrus malus 7	A.	Europe; Anatolia; south of the Caucasus.
Quince—Cydonia vulgaris 7	A.	North of Persia; south of the Caucasus; Anatolia.
Loquat—Eriobotrya japonica 7	(?)	Japan.
Pomegranate—Punica granatum 8	A.	Persia; Afghanistan; Beluchistan.
Rose apple—Jambosa vulgaris 7	B.	Malay Archipelago; Cochin China; Burma; northeast of India.
Malay apple—Jambosa malaccensis 7	B.	Malay Archipelago; Malacca.
Bottle gourd—Cucurbita lagenaria (1)	C.	India; Moluccas; Abyssinia.
Spanish gourd—C. maxima (1)	C. (?)	Guinea.
Melon—Cucumis melo (1)	C.	India; Beluchistan; Guinea.
Watermelon—Citrullus vulgaris (1)	A.	Tropical Africa.
Cucumber—Cucumis sativus (1)	A.	India.
West Indian gherkin—Cucumis anguria (1)	C. (?)	Tropical Africa.(?)
White gourd-melon—Benincasa hispida (1)	(?)	Japan; Java.
Towel gourd—Luffa cylindrica (1)	C.	India.
Angular luffa—Luffa acutangula (1)	C.	India; Malay Archipelago.

Species native to the Old World—Continued.

CULTIVATED FOR THE FRUITS—Continued.

Name and duration.	Date.	Origin.
Snake gourd—Trichosanthes anguina (1)	C.	India.(?)
Gooseberry—Ribes grossularia 5	C.	Temperate Europe; north of Africa; Caucasus; western Himalayas.
Red currant—Ribis rubrum 5	C.	Northern and temperate Europe; Siberia; Caucasus; Himalayas; northeast of the United States.
Black currant—Ribis nigrum 5	C.	Northern and central Europe; Armenia; Siberia; Manchuria; western Himalayas.
Kaki—Diospyros Kaki 7	(?)	Japan; northern China.
Date plum—Diospyros lotos 7	(?)	China; India; Afghanistan; Persia; Armenia; Anatolia.
Olive—Olea europea 7	A.	Syria; southern Anatolia and neighboring Islands.
Aubergine—Solanum melongena (1)	A.	India.
Fig—Ficus carica 7	A.	Center and south of the Mediterranean basin, from Syria to the Canaries.
Breadfruit—Artocarpus incisa 8	(?)	Sunda Isles.
Jack fruit—Artocarpus integrifolia 8	B.	India.
Date palm—Phoenix dactylifera 8	A.	Western Asia and Africa from the Euphrates to the Canaries.
Banana—Musa sapientum 7	A.	Southern Asia.
Oil palm—Elaeis guineensis 8	(?)	Guinea.

CULTIVATED FOR THE SEEDS.

1. NUTRITIVE.

Litchi—Nephelium Litchi 7	(?)	Southern China; Cochin China.
Longan—Nephelium longana 7	(?)	India; Pegu.
Rambutan—Nephelium lappaceum 7	(?)	Do.
Pistachio—Pistacia vera 6	C.	Syria.
Bean—Fava vulgaris (1)	A.	South of the Caspian (?).
Lentil—Ervum lens (1)	A.	Western temperate Asia; Greece; Italy.
Chick-pea—Cicer arietinum (1)	A.	South of the Caucasus and of the Caspian.
Lupin—Lupinus albus (1)	B.	Sicily; Macedonia; south of the Caucasus.
Egyptian lupin—Lupinus termis (1)	A.	From Corsica to Syria.
Field pea—Pisum arvense (1)	(?)	Italy.
Garden pea—Pisum sativum (1)	B.	From the south of the Caucasus to Persia (?); north India (?).
Soy—Dolichos soja (1) 6	A.	Cochin China; Japan; Java.
Pigeon pea—Cajanus indicus	C.	Equatorial Africa.
Carob—Ceratonia siliqua 8	A. (?)	Southerncoast of Anatolia; Syria; Cyrenaica (?).
Moth—Phaseolus aconitifolius (1)	C.	India.
Three-lobed kidney bean—Phaseolus trilobus4(1)	B.	India; tropical Africa.
Green gram—Phaseolus mungo 1 (1)	B. (?)	India.
Wali—Phaseolus lablab (1)	C.	Do.
Lubia—Phaseolus lubia (1)	C.	Western Asia (?).
Bambarra ground nut—Voandzeia subterranea (1)	(?)	Intertropical Africa.
Buckwheat—Fagopyrum esculentum (1)	C.	Manchuria; central Siberia.
Tartary buckwheat—Fagopyrum tartaricum (1).	C.	Tartary; Siberia to Dahuria.
Notch-seeded buckwheat—Fagopyrum emarginatum (1).	(?)	Western China; eastern Himalayas.
Kiery—Amarantus frumentaceus (1)	(?)	India.
Chestnut—Castanea vulgaris 4	(?)	From Portugal to the Caspian Sea; eastern Algeria. Varieties: Japan; North America.
Wheat—Triticum vulgare and varieties (?) (1)	A.	Region of the Euphrates.
Spelt—Triticum spelta (1)	A.	Derived from the preceding (?).
One-grained wheat—Triticum monococcum (1)	(?)	Servia; Greece; Anatolia (if the identity with the Triticum boeóticum be admitted).
Two-rowed barley—Hordeum distichon (1)	A.	Western temperate Asia.
Common barley—Hordeum vulgare (1)	(?)	Derived from the preceding (?).
Six-rowed barley—Hordeum hexastichon (1)	A.	Do.
Rye—Secale cereale (1)	B.	Eastern temperate Europe (?).
Common oats—Avena sativa (1)	B.	Do.
Eastern oats—Avena orientalis (1)	C. (?)	Western Asia (?).
Common millet—Panicum miliaceum (1)	A.	Egypt; Arabia.
Italian millet—Panicum italicum (1)	A.	China; Japan; Indian Archipelago (?).
Sorghum—Holcus sorghum (1)	A.	Tropical Africa (?).
Sweet sorghum—Holcus saccharatus (1)	(?)	Do.
Coracan—Eleusine coracana (1)	B.	India.
Rice—Oryza sativa (1)	A.	India; southern China (?).

Species native to the Old World—Continued.

CULTIVATED FOR THE SEEDS—Continued.

2. VARIOUS USES.

Name and duration.	Date.	Origin.
Poppy—Papaver somniferum (1)	B.	Derived from P. setiferum of the Mediterranean basin.
White mustard—Sinapis alba 1	B.	Temperate and southern Europe; north of Africa; western temperate Asia.
Black mustard—Sinapis nigra 1	B.	
Gold of pleasure—Camelina sativa (1)	B. (?)	Temperate Europe; Caucasus; Siberia.
Herbaceous cotton—Gossypium herbaceum 5 (1).	B.	India.
Tree cotton—Gossypium arboreum 6	B. (?)	Upper Egypt.
Arabian coffee—Coffea arabica 7	C.	Tropical Africa; Mosambique; Abyssinia; Guinea.
Liberian coffee—Coffea liberica 8	C.	Guinea; Angola.
Sesame—Sesamum indicum (1)	A.	Sunda Isles.
Nutmeg—Myristica fragrans 7	B.	Moluccas.
Castor-oil plant—Ricinus communis 6	A.	Abyssinia; Sennaar; Kordofan.
Walnut—Juglans regia 8	(?)	Eastern temperate Europe; temperate Asia.
Black pepper—Piper nigrum 6	B.	India.
Long pepper—Piper longum 5	B.	Do.
Medicinal pepper—Piper officinalis 5	B.	Malay Archipelago.
Betel pepper—Piper betle 6	B.	Do.
Areca nut—Areca catechu 7	B.	Do.
Cocoa nut—Cocos nucifera 3	(?)	Malay Archipelago (?); Polynesia (?)

Species of American origin.

CULTIVATED FOR THE UNDERGROUND PARTS.

Arracacha—Arracacha esculenta (1) 4	E.	New Granada (?).
Jerusalem artichoke—Helianthus tuberosus 4	E. (?)	North America (Indiana).
Potato—Solanum tuberosum 4	E.	Chili; Peru (?).
Sweet potato—Convolvulus batatas 4	D.	Tropical America (where?).
Manioc—Manihot utilissima 6	E.	East of tropical Brazil.
Arrowroot—Maranta arundinacea 7	(?)	Tropical (continental?) America.
Maté—Ilex paraguariensis 7	D.	Paraguay and western Brazil.
Coca—Erythroxylon coca 7	D.	East of Peru and Bolivia.
Quinine—Cinchona calisaya 7	F.	Bolivia; southern Peru.
Crown bark—Cinchona officinalis	F.	Ecuador (province of Loxa).
Red cinchona bark—Cinchona succirubra 7	F.	Ecuador (province of Cuenca).
Tobacco—Nicotiana tabacum (1)	D.	Ecuador and neighboring countries.
Nicotiana rustica (1)	E.	Mexico (?); Texas (?); California (?).
American aloe—Agave americana 7	E.	Mexico.

CULTIVATED FOR THE FRUITS.

Sweet sop—Anona squamosa 7	(?)	West India Isles.
Sour sop—Anona muricana	(?)	Do.
Custard apple—Anona reticulata 7	(?)	West India Isles; New Granada.
Chirimoya—Anona cherimolia 7	E.	Ecuador; Peru (?).
Mammee apple—Mammea americana 8	(?)	West India Isles.
Cashew nut—Anacardium occidentale 8	(?)	Tropical America.
Virginian strawberry—Fragaria virginiana 4	F.	Temperate North America.
Chile strawberry—Fragaria chiloensis 4	F.	Chile.
Guava—Psidium guayava 7	E.	Continental Tropical America.
Pumpkin and squash—Cucurbita pepo and Melopepo (1).	E.	Temperate North America.
Prickly pear—Optunia ficus indica 7	E.	Mexico.
Chocho—Sachium edule (1)	E.	Mexico (?); Central America.
Star apple—Chrysophyllum cainito 7	E.	West India Isles; Panama.
Caimito—Lucuma caimito 7	E.	Peru.
Marmalade plum—Lucuma mammosa 7	E.	Valley of the Orinoco.
Sapodilla—Sapota achras 7	E.	Campeachy; Isthmus of Panama; Venezuela.
Persimmon—Diospyros virginiana 7	F.	Eastern States of America.
Annual capsicum—Capsicum annum (1)	E.	Brazil (?).
Shrubby capsicum—Capsicum frutescens 6	E.	From the east of Peru to Bahia.
Tomato—Lycopersicum esculentum (1)	E.	Peru.
Avocado pear—Persea gratissima 8	E.	Mexico.
Papaw—Papaya vulgaris 7	E.	West Indies; Central America.
Pineapple—Ananassa sativa 4	E.	Mexico; Central America; Panama; New Granada; Guiana (?); Bahia (?).

Species of American origin—Continued.

CULTIVATED FOR THE SEEDS.

1. Nutritious.

Name and duration.	Date.	Origin.
Cacao—Theobroma cacao 7	D.	Amazon and Orinoco valleys; Panama (?); Yucatan (?).
Sugar bean—Phaseolus lunatus 4	E.	Brazil.
Quinoa—Chenopodium quinoa 1	E.	New Granada; Peru (?); Chile (?).
Maize—Zea mays (1)	D.	New Granada (?).

2. Various Uses.

Name and duration.	Date.	Origin.
Arnotto—Bixa orellana	D.	Tropical America.
Barbados cotton—Gossypium barbadense 8	(?)	New Granada (?); Mexico (?); West Indies.
Earthnuts—Arachis hypogæa (1)	E.	Brazil.
Madia—Madia sativa (1)	E.	Chile; California.

CRYPTOGRAM CULTIVATED FOR THE WHOLE PLANT.

Name and duration.	Date.	Origin.
Mushroom—Agaricus campestris 4	C.	Northern Hemisphere.

Species of unknown or entirely uncertain origin.—Common haricot—Phaseolus vulgaris (1); Musk gourd—Cucurbita moschata (1); Fig-leaved gourd—Cucurbita ficifolia.

GENERAL OBSERVATIONS AND CONCLUSIONS.

REGIONS WHERE CULTIVATED PLANTS ORIGINATED.

In the beginning of the nineteenth century the origin of most of our cultivated species was unknown. Linnæus made no efforts to discover it, and subsequent authors merely copied the vague or erroneous expressions by which he indicated their habitations. Alexander von Humboldt expressed the true state of the science in 1807 when he said: "The origin, the first home of the plants most useful to man, and which have accompanied him from the remotest epochs, is a secret as impenetrable as the dwelling of all our domestic animals. * * * We do not know what region produced spontaneously wheat, barley, oats, and rye. The plants which constitute the natural riches of all the inhabitants of the Tropics, the banana, the papaw, the manioc, and maize, have never been found in a wild state. The potato presents the same phenomenon."[a]

At the present day, if a few cultivated species have not yet been seen in a wild state, this is not the case with the immense majority. We know at least, most frequently, from what country they first came. This was already the result of my work of 1855, with modern and more extensive research has confirmed in almost all points. This research has been applied to 247 species,[b] cultivated on a large scale by agriculturists or in kitchen gardens and orchards. I might have added a few rarely cultivated or but little known, or of which the cultivation has been abandoned, but the statistical results would be essentially the same.

Out of the 247 species which I have studied, the Old World has furnished 199, America 45, and 3 are still uncertain.

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[a] Essai sur la Geographie des plantes, p. 28.

[b] Counting two or three forms which are perhaps rather very distinct races.

No species was common to the tropical and austral regions of the two hemispheres before cultivation. *Allium schoenoprasum*, the hop (*Humulus lupulus*), the strawberry (*Fragaria vesca*), the currant (*Ribis rubrum*), the chestnut (*Castanea vulgaris*), and the mushroom (*Agaricus campestris*) were common to the northern regions of the Old and New Worlds. I have reckoned them among the species of the Old World, since their principal habitation is there and there they were first cultivated.

A great number of species originated at once in Europe and western Asia, in Europe and Siberia, in the Mediterranean basin and western Asia, in India and the Asiatic Archipelago, in the West Indies and Mexico, in these two regions and Colombia, in Peru and Brazil, or in Peru and Colombia, etc., etc. They may be counted in the table. This is a proof of the impossibility of subdividing the continents and of classing the islands in well-defined natural regions. Whatever be the method of division, there will always be species common to two, three, four, or more regions, and others confined to a small portion of a single country. The same facts may be observed in the case of uncultivated species.

A noteworthy fact is the absence in some countries of indigenous cultivated plants. For instance, we have none from the Arctic or Antarctic regions, where, it is true, the floras consist of but few species. The United States, in spite of their vast territory, which will soon support hundreds of millions of inhabitants, only yield, as nutritious plants worth cultivating, the Jerusalem artichoke and the gourds. *Zizana æquatica*, which the natives gathered wild, is a grass too inferior to our cereals and to rice to make it worth the trouble of planting it. They had a few bulbs and edible berries, but they have not tried to cultivate them, having early received the maize, which was worth far more.

Patagonia and the Cape have not furnished a single species. Australia and New Zealand have furnished one tree, *Eucalyptus globulus*, and a vegetable, not very nutritious, the *Tetragonia*. Their floras were entirely wanting in graminæ similar to the cereals, in leguminous plants with edible seeds, in Cruciferæ with fleshy roots.[a] In the moist tropical region of Australia, rice and *Alocasia macrorrhiza* have been found wild, or perhaps naturalized, but the greater part of the country suffers too much from drought to allow these species to become widely diffused.

In general, the austral regions had very few annuals, and among their restricted number none offered evident advantages. Now annual species are the easiest to cultivate. They have played a great part in the ancient agriculture of other countries.

In short, the original distribution of cultivated species was very unequal. It had no proportion with the needs of man or the extent of territory.

NUMBER AND NATURE OF CULTIVATED SPECIES AT DIFFERENT EPOCHS.

The species marked A in the table on pages 437-446 must be regarded as of very ancient cultivation. They are 44 in number. Some of the species marked B are probably as ancient, though it is impossible to prove it. The five American species marked D are especially plants provided with roots, seeds, and fruits proper for the food of man. Afterwards come a few species having fruits agreeable to the taste, or textile, tinctorial, oil-producing plants, or yielding drinks by infusion or fermentation. There are among these only two green vegetables and no fodder. The orders which predominate are the Cruciferæ, Leguminosæ, and Graminaceæ.

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[a] See the list of the useful plants of Australia by Sir J. Hooker, Flora Tasmania, p. cx.; and Bentham, Flora Australiensis, vii, p. 156.

The number of annuals is twenty-two out of the forty-four, or 50 per cent. Out of five American species marked D, two are annuals. In the category A there are two biennials, and D has none. Among all the Phanerogams the annuals are not more than 50 per cent, and the biennials 1 or at most 2 per cent. It is clear that at the beginning of civilization plants which yield an immediate return are most prized. They offer, moreover, this advantage, that their cultivation is easily diffused or increased, either because of the abundance of seed or the same species may be grown in summer in the North, and in winter or all the year round in the Tropics.

Herbaceous perennial plants are rare in categories A and D. They are only from 2 to 4 per cent, unless we include *Brassica oleracea* and the variety of flax which is usually perennial (*L. angustifolium*), cultivated by the Swiss lake dwellers. In nature, herbaceous perennials constitute about 40 per cent of the Phanerogams.[a]

A and D include twenty ligneous species out of forty-nine, that is about 41 per cent. They are in the proportion of 43 per cent of the Phanerogams.

Thus the earliest husbandmen employed chiefly annuals or biennials, rather fewer woody species, and far fewer herbaceous perennials. These differences are due to the relative facility of cultivation and the proportion of the evidently useful species in each division.

The species of the Old World marked B have been in cultivation for more than two thousand years, but perhaps some of them belong to category A. The American species marked E were cultivated before the discoveries of Columbus, perhaps for more than two thousand years. Many other species marked "(?)" in the table date probably from an ancient epoch, but as they chiefly exist in countries without a literature and without archæological records, we do not know their history. It is useless to insist upon such doubtful categories; on the other hand, the plants which we know to have been first cultivated in the Old World less than two thousand years ago, and in America since its discovery, may be compared with plants of ancient cultivation.

These species of modern cultivation number 61 in the Old World, marked C, and 6 in America, marked F; 67 in all.

Classed according to their duration, they number 37 per cent annuals, 7 to 8 per cent biennials, 33 per cent herbaceous perennials, and 22 to 23 per cent woody species.

The proportion of annuals or biennials is also here larger than in the whole number of plants, but it is not so large as among species of very ancient cultivation. The proportions of perennials and woody species are less than in the whole vegetable kingdom, but they are higher than among the species A of very ancient cultivation.

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[a] The proportions which I give for the Phanerogams collectively are based upon an approximative calculation made with the aid of the first 200 pages of Steudel's Nomenclator. They are justified by the comparison with several floras.

The plants cultivated for less than two thousand years are chiefly artificial fodders, which the ancients scarcely knew; then bulbs, vegetables, medicinal plants (Cinchonas), plants with edible fruits, or nutritious seeds (buckwheats), or aromatic seeds (coffee).

Men have not discovered and cultivated within the last two thousand years a single species which can rival maize, rice, the sweet potato, the potato, the breadfruit, the date cereals, millets, sorghums, the banana, and soy. These date from three, four, or five thousand years, perhaps even in some cases six thousand years. The species first cultivated during the Græco-Roman civilization and later nearly all answer to more varied or more refined needs. A great dispersion of the ancient species from one country to another took place, and at the same time a selection of the best varieties developed in each species. The introductions within the last two thousand years took place in a very irregular and intermittent manner. I can not quote a single species cultivated for the first time after that date by the Chinese, the great cultivators of ancient times. The peoples of southern and western Asia innovated in a certain degree by cultivating the buckwheats, several cucurbitaceæ, a few alliums, etc. In Europe the Romans and several peoples in the Middle Ages introduced the cultivation of a few vegetables and fruits and that of several fodders. In Africa a few species were then first cultivated separately. After the voyages of Vasco di Gama and of Columbus a rapid diffusion took place of the species already cultivated in either hemisphere. These transports continued during three centuries without any introduction of new species into cultivation. In the two or three hundred years which preceded the discovery of America and the two hundred which followed, the number of cultivated species remained almost stationary. The American strawberries, *Diospyros virginiana*, sea kale, and *Tetragonia expansa*, introduced in the eighteenth century, have but little importance. We must come to the middle of the present century to find new cultures of any value from the utilitarian point of view, such as *Eucalyptus globulus* of Australia and the *Cinchonas* of South America.

The mode of introduction of the latter species shows the great change which has taken place in the means of transport. Previously the cultivation of a plant began in the country where it existed, whereas the Australian *Eucalyptus* was first planted and grown in Algeria, and the *Cinchonas* of America in the south of Asia. Up to our own day botanical or private gardens had only diffused species already cultivated somewhere; now they introduce absolutely new cultures. The royal garden at Kew is distinguished in this respect, and other botanical gardens and acclimatization societies in England and elsewhere are making similar attempts. It is probable that tropical countries will greatly benefit by this in the course of a century. Others will also find their advantage from the growing facility in the transport of commodities.

When a species has been once cultivated it is rarely, perhaps never, completely abandoned. It continues to be here and there cultivated in backward countries or those whose climate is especially favorable. I have passed over some of these species which are nearly abandoned, such as dyer's woad (*Isatis tinctoria*), mallow (*Malva sylvestris*), a vegetable used by the Romans, and certain medicinal plants formerly much used, such as fennel, cummin, etc.; but it is certain that they are still grown in some places.

The competition of species causes the cultivation of some to diminish, of others to increase; besides, vegetable dyes and medicinal plants are rivaled by the discoveries of chemists. Woad, madder, indigo, mint, and several simples must give way before the invasion of chemical products. It is possible that men may succeed in making oil, sugar, and flour, as honey, butter, and jellies are already made, without employing organic substances. Nothing, for instance, would more completely change agricultural conditions than the manufacture of flour from its own inorganic elements. In the actual state of science there are still products which will be more and more required of the vegetable kingdom; these are textile substances, tan, india rubber, gutta-percha, and certain spices. As the forests where these are found are gradually destroyed, and these substances are at the same time more in demand, there will be the greater inducement to cultivate certain species.

These usually belong to tropical countries. It is in these regions also, particularly in South America, that fruit trees will be more cultivated—those of the order Anonaceæ, for instance, of which the natives and botanists already recognize the value. Probably the number of plants suitable for fodder and of forest trees which can live in hot, dry countries will be increased. The additions will not be numerous in temperate climates, nor especially in cold regions.

From these data and reflections it is probable that at the end of the nineteenth century men will cultivate on a large scale and for use about 300 species. This is a small proportion of the 120,000 or 140,000 in the vegetable kingdom; but in the animal world the proportion of creatures subject to the will of man is far smaller. There are not perhaps more than 200 species of domestic animals—that is, reared for our use—and the animal kingdom reckons millions of species. In the great class of molluscs the oyster alone is cultivated, and in that of the Articulata, which counts ten times more species than the vegetable kingdom, we can only name the bee and two or three silk-producing insects. Doubtless the number of species of animals and vegetables which may be reared or cultivated for pleasure or curiosity is very large—witness menageries and zoological and botanical gardens—but I am only speaking here of useful plants and animals in general and customary employment.

CULTIVATED PLANTS KNOWN OR NOT KNOWN IN A WILD STATE.

Science has succeeded in discovering the geographical origin of nearly all cultivated species; but there is less progress in the knowledge of species in a natural state—that is, wild, far from cultivation and dwellings. There are species which have not been discovered in this condition and others whose specific identity and truly wild condition are doubtful.

In the following enumeration I have classed the species according to the degree of certainty as to the wild character, and the nature of the doubts where such exist.[a]

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[a] The species in italics are of very ancient cultivation (A or D); those marked with an asterisk have been less than two thousand years in cultivation (C or F).

1. Spontaneous species—that is, wild—seen by several botanists far from dwellings and cultivation, with every appearance of indigenous plants, and under a form identical with one of the cultivated varieties. These are the species which are not enumerated below; they are 169 in number.

Among these 169 species 31 belong to the categories A and D, of very ancient cultivation, 56 have been in cultivation less than two thousand years, C, and the others are of modern or unknown date.

2. Seen and gathered in the same conditions, but by a single botanist in a single locality. Three species: Cucurbita maxima, *Faba vulgaris*, *Nicotiana Tabacum*.

3. Seen and mentioned but not gathered in the same conditions by one or two authors and botanists, more or less ancient, who may have been mistaken. Two species: *Carthamus tinctorius*, *Triticum vulgare*.

4. Gathered wild by botanists in several localities under a form slightly different to those which are cultivated, but which most authors have no hesitation in classing with the species. Four species: *Olea europæa*, *Oryza sativa*, Solanum tuberosum, *Vitis vinifera*.

5. Wild, gathered by botanists in several localities under forms considered by some botanists as constituting different species, while others treat them as varieties. Fifteen species: Allium ampeloprasum porrum, Cichorium Endivia, var. *Crocus sativus*, var., *Cucumis melo, Cucurbita Pepo, Helianthus tuberosus, Latuca scariola sativa, *Linum usitatissimum annuum*, Lycopersicum esculentium, Papaver somniferum, Pyrus nivalis var., *Ribis grossularia, Solanum Melongena, Spinacia oleracea var., Triticum monococcum.

6. Subspontaneous—that is, half-wild—similar to one or other of the cultivated forms, but possibly plants escaped from cultivation, judging from the locality. Twenty-four species: Agava americana, Amarantus gangeticus, *Amygdalus persica*, Areca catechu, *Avena orientalis, Avena sativa, Cajanus indicus, *Cicer arietinum*, Citrus decumana, Cucurbita mischota, Dioscorea japonica, Ervum Ervilia, *Ervum lens*, Fagopyrum emarginatum, Gossypium barbadense, Holcus saccharatus, *Holcus sorghum*, Indigofera tinctoria, Lepidum sativum, Maranta arundinacea, Nicotiana rustica, *Panicum miliaceum*, Raphanus sativus, Spergula arvensis.

7. Subspontaneous like the preceding, but different enough from cultivated varieties to lead the majority of authors to regard them as distinct species. Three species: *Allium ascalonicum (variety of *A. cepa ?*), Allium scorodoprasum (variety of A. sativum ?), Secale cereale (variety of one of the perennial species of Secale ?).

8. Not discovered in a wild state, nor even half-wild, derived perhaps from cultivated species at the beginning of agriculture, but too different not to be commonly regarded as distinct species. Three species: *Hordeum hexastichon* (derived from *H. distichon?*), *Hordeum vulgare* (derived from *H. distichon?*), *Triticum spelta* (derived from *T. vulgare?*).

9. Not discovered in a wild state, nor even half-wild, but originating in countries which are not completely explored, and belonging perhaps to little known wild species of these countries. Six species: Arachis hypogea, Carophyllus aromaticus, *Convolvulus batatas*, Dolichos lubia, Manihot utilissima, *Phaseolus vulgaris*.

10. Not found in a wild state, nor even half-wild, but originating in countries which are not sufficiently explored, or in similar countries, which can not be defined, more different than the latter from known wild species. Eighteen species: Amorphophallus konjak, Arracacha esculenta, Brassica chinénsis, Capsicum annuum, Chenopodium quinoa,[a] Citrus nobilis, Cucurbita ficifolia. Dioscorea alata, Dioscorea Batatas, Dioscorea sativa, Eleusine coracana, Lucuma mammosa, Nephelium Litchi, Pisum sativum, Saccharum officinarum, Sechium edule, Triconsanthes anguina, *Zea mays.*

Total, 247 species.

These figures show that there are 193 species known to be wild, 27 doubtful, as half-wild, and 27 not found wild.

I believe that these last will be found some time or other, if not under one of the cultivated forms, at least in an allied form called species or variety, according to the author. To attain this result, tropical countries will have to be more thoroughly explored, collectors must be more attentive to localities, and more floras must be published of countries now little known, and good monographs of certain genera based upon the characters which vary least in cultivation.

A few species, having their origin in countries fairly well explored, and which it is impossible to confound with others, because each is unique in its genus, have not been found wild, or only once, which leads us to suppose that they are extinct in nature or rapidly becoming so. I allude to maize and the bean. (See pp. 316 and 387.) I mention also, in Article IV, other plants which appear to be becoming extinct in the last few thousand years. These last belong to genera which contain many species, which renders the hypothesis less probable;[b] but on the other hand, they are rarely seen at a distance from cultivated ground, and they hardly ever become naturalized, that is, wild, which shows a certain feebleness or a tendency to become the prey of animals and parasites.

The 67 species cultivated for less than two thousand years (C, F) are all found wild, except the species marked with an asterisk, which have not been found or which are subject to doubts. This is a proportion of 83 per cent.

What is more remarkable is that the great majority of species cultivated for more than four thousand years (A), or in America for three thousand or four thousand years (D), still exist wild in a form identical with some one of the cultivated varieties. Their number is 31 out of 49, or 63 per cent. In categories 9 and 10 there are only 2 of these species of very ancient cultivation, or 4 per cent, and these are 2 species which probably exist no longer as wild plants.

I believe, a priori, that a great number of the species cultivated for more than four thousand years would have altered from their original condition to such a degree that they could no longer be recognized among wild plants. It appears, on the contrary, that the forms anterior to cultivation have commonly remained side by side with those which cultivators employed and propagated from century to century. This may be explained in two ways: (1) The period of four thousand years is short compared to the duration of most of the specific forms in phanerogamous plants. (2) The cultivated species receive, outside of cultivated ground, continual reenforcements from the seeds which man, birds, and different natural agents disperse and transport in a thousand ways. Naturalization produced in this manner often confounds the wild plants with the cultivated ones, and the more easily that they fertilize each other since they belong to the same species. This fact is clearly demonstrated in the case of a plant of the Old World cultivated in America, in gardens, and which later becomes naturalized on a large scale in the open country or the woods, like the cardoon at Buenos Aires, and the oranges in several American countries. Cultivation widens areas, and supplements the deficits which the natural reproduction of the species may present. There are, however, a few exceptions, which are worth mentioning in a separate article.

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[a] Since this list was printed I have been informed that the quinoa is wild in Chili. Some of the figures need modification in consequence of this error.

[b] For reasons which I can not here express, monotypical genera are for the most part in process of extinction.

CULTIVATED PLANTS WHICH ARE EXTINCT OR BECOMING EXTINCT IN A WILD STATE.

These species to which I allude present three remarkable characters:

1. They have not been found wild, or only once or twice, and often doubtfully, although the regions whence they come have been visited by several botanists.
2. They have not the faculty of sowing themselves, and propagating indefinitely outside cultivated ground; in other terms, in such cases they do not pass out of the condition of adventitious plants.
3. It can not be supposed that they are derived within historic times from certain allied species.

These three characters are found united in the following species: Bean (*Faba vulgaris*), chick-pea (*Cicer arietinum*), ervilla (*Ervum ervilia*), lentil (*Ervum lens*), tobacco (*Nicotiana tabacum*), wheat (*Triticum vulgare*), *maize* (*Zea mays*). The sweet potato (*Convolvulus batatas*) should be added if the kindred species were better known to be distinct, and the carthamine (*Carthamus tinctorius*) if the interior of Arabia had been explored and we had not found a mention of the plant in an Arabian author.

All these species, and probably others of little-known countries or genera, appear to be extinct or on their way to become so. Supposing they ceased to be cultivated, they would disappear, whereas the majority of cultivated plants have become somewhere naturalized and would persist in a wild state.

The seven species mentioned just now, excepting tobacco, have seeds full of fecula, which are the food of birds, rodents, and different insects, and have not the power of passing entire through their alimentary canal. This is probably the sole or principal cause of their inferiority in the struggle for existence.

Thus my researches into cultivated plants show that certain species are extinct or becoming extinct since the historical epoch, and that not in small islands but on vast continents without any great modifications of climate. This is an important result for the history of all organic beings in all epochs.

CONCLUDING REMARKS.

1. Cultivated plants do not belong to any particular category, for they belong to 51 different families. They are, however, all phanerogamous except the mushroom (*Agaricus campestris*).

2. The characters which have most varied in cultivation are, beginning with the most variable: (*a*) The size, form, and color of the fleshy parts, whatever organ they belong to (root, bulb, tubercle, fruit, or seed) and the abundance of fecula, sugar, and other substances which are contained in these parts; (*b*) the number of seeds, which is often in inverse ratio to the development of the fleshy parts of the plant; (*c*) the form, size, or pubescence of the floral organs which persist around the fruits or seeds; (*d*) the rapidity of the phenomena of vegetation, whence often results the quality of ligneous of herbaceous plants, and of perennial, biennial, or annual.

The stems, leaves, and flowers vary little in plants cultivated for those organs. The last formations of each yearly or biennial growth vary most; in other terms, the results of vegetation vary more than the organs which cause vegetation.

3. I have not observed the slightest indication of an adaptation to cold. When the cultivation of a species advances toward the north (maize, flax, tobacco, etc.) it is explained by the production of early varieties, which can ripen before the cold season, or by the custom of cultivating in the north in summer the species which in the south are sown in winter. The study of the northern limits of wild species had formerly led me to the same conclusion, for they have not changed within historic times, although the seeds are carried frequently and continually to the north of each limit. Periods of more than four or five thousand years or changements of form and duration are needed apparently to produce a modification in a plant which will allow it to support a greater degree of cold.

4. The classification of varieties made by agriculturists and gardeners is generally based on those characters which vary most (form, size, colors, taste of the fleshy parts, beard in the ears of corn, etc.). Botanists are mistaken when they follow this example; they should consult those more fixed characters of the organs for the sake of which the species are not cultivated.

5. A noncultivated species being a group of more or less similar forms, among which subordinate groups may often be distinguished (races, varieties, subvarieties), it may have happened that two or more of these slightly differing forms may have been introduced into cultivation. This must have been the case especially when the habitation of a species is extensive, and yet more when it is disjunctive. The first case is probably that of the cabbage (*Brassica*), of flax, bird cherry (*Prunus avium*), the common pear, etc. The second is probably that of the gourd, the melon, and trefoil haricot, which existed previous to cultivation both in India and Africa.

6. No distinctive character is known between a naturalized plant which arose several generations back from a cultivated plant and a wild plant sprung from plants which have always been wild. In any case, in the transition from cultivated plant to wild plant the particular features which are propagated by grafting are not preserved by seedlings. For instance, the olive tree which has become wild is the *oleaster*, the pear bears smaller fruits, the Spanish chestnut yields a

common fruit. For the rest, the forms naturalized from cultivated species have not yet been sufficiently observed from generation to generation. M. Sagot has done this for the vine. It would be interesting to compare in the same manner with their cultivated forms Citrus, Persica, and the cardoon, naturalized in America, far from their original home, as also the Agave and the prickly pear, wild in America, with their naturalized varieties in the Old World. We should know exactly what persists after a temporary state of cultivation.

7. A species may have had, previous to cultivation, a restricted habitation, and subsequently occupy an immense area as a cultivated and sometimes a naturalized plant.

8. In the history of cultivated plants I have noticed no trace of communication between the peoples of the Old and New worlds before the discovery of America by Columbus. The Scandinavians, who had pushed their excursions as far as the north of the United States, and the Basques of the Middle Ages, who followed whales perhaps as far as America, do not seem to have transported a single cultivated species. Neither has the Gulf Stream produced any effect. Between America and Asia two transports of useful plants perhaps took place, the one by man (the Batata, or sweet potato), the other by the agency of man or of the sea (the cocoanut palm).

THE PRINCIPAL DROUGHTS IN THE PERIOD FROM 1870 TO 1906 AND THEIR INFLUENCE ON THE CORN CROP.

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Prof. A. J. Henry, in the Yearbook of the Department of Agriculture for 1907, stated:

> The years of minimum rainfall or drought from 1871 to 1896 fall in groups separated by irregular intervals. The first group centers about 1871; the second, 1881; the third, 1887; and the last, 1894–95. The drought of 1887 was severe in some months, but not consistently so throughout the entire season. The droughts of 1881 and 1894 were widespread and severe. The former was confined principally to States east of the Alleghenies, while the latter was felt from Nebraska eastward to Massachusetts and southward to Alabama.
>
> Prior to 1870 the few records available indicate a severe drought in 1860 in Kansas and western Missouri, more severe than has since been experienced. Widespread drought in the central valleys and Lake region also occurred in 1863. The periods of extensive drought in chronological order are, therefore, 1860, 1863, 1870–71, 1881, 1887, and 1894–95.[a]
>
> There have been, of course, several local droughts in various portions of the United States during the intervening years, as there must always be in a territory of such vast extent.
>
> The smallest amount (of rainfall) that may be expected in the great corn and wheat regions of the central valleys does not vary greatly from 9 to 10 inches (from April 1 to September 30). In the South Atlantic and Gulf States the fall in the year of least rain ranges from a maximum of 20 inches in central and northern Florida to less than 15 inches in the Mississippi Valley and a considerable fringe of country to the westward. The amount of rain that falls in the year of severe drought in the greater part of the Southeastern States is sufficient for the growth and maturity of staple crops if properly distributed. Success in agricultural pursuits, so far as conditioned upon the rainfall, should therefore be more easily achieved in the Southeastern States than elsewhere, particularly in regions of precarious rainfall.[b]

In Bulletin Q of the Weather Bureau, Climatology of the United States, by Henry, published in 1906, attention is called especially to the severe droughts of 1870, 1874, 1881, 1886, 1887, 1893, 1894, and 1895. The following pages contain extracts from Bulletin Q and data obtained from articles on weather and crop conditions, published annually in the Yearbooks of the Department of Agriculture.

DROUGHT OF 1870.

Local in character; southern Ohio, Wisconsin, and Missouri.

In southern Ohio the rainfall from August 1 to September 30 was about 1½ inches.

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[a] In addition to the drought years mentioned above, a severe drought occurred in 1901, which cut the corn crop very short. This drought prevailed from June 24 to July 29—thirty-six days—over the States of the central valleys and middle Rocky Mountain region, and also in lesser degree in the Lake region, the Ohio Valley, and Tennessee. A very serious drought also prevailed during 1890 over the greater portion of the corn belt.

[b] A. J. Henry, Rainfall of the Crop Season, Yearbook, U. S. Dept. Agr., 1897.

At Milwaukee the precipitation for April was ½ inch; May, 6/10 inch; June, 2½ inches.

Dry weather also prevailed in Missouri.

The drought apparently had no effect on corn; in fact, the average crops were greater for 1870 than for preceding year, being 6 bushels above the average for forty years in Ohio, 7 above Wisconsin, but 3 below the average in Missouri.

DROUGHT OF 1874.

A severe drought prevailed in Kansas, Nebraska, Iowa, Missouri, Illinois, and Indiana, and in less marked degree in the middle and lower Mississippi valleys.

Eastern Kansas was affected the worst, where for a period of eighty days slightly over 2 inches of rain fell. At Leavenworth, Kans., from June 15 to July 8—twenty-four days—practically no rain fell.

Average yield of corn in bushels per acre.

State.	1873.	1874.	1875.	Normal.
Indiana	25.6	27.0	34.0	31.4
Illinois	21.0	18.0	34.3	30.3
Iowa	29.0	29.2	35.0	32.4
Missouri	23.5	16.0	36.6	29.5
Nebraska	35.0	10.0	40.0	30.4
Kansas	39.1	10.5	40.0	27.3
Kentucky	29.5	25.0	33.3	26.4
Tennessee	22.5	16.8	26.5	22.1
Mississippi	15.5	13.8	18.0	15.0
Louisiana	16.5	15.5	15.5	16.8
Arkansas	23.5	12.6	30.0	21.0

NOTE.—This drought prevailed in 11 States, 8 of which showed reduced production of corn as compared with the previous year (1873), and all showed lower yields than those of the following year (1875). The yields in all these States were also below the normal for the forty years, being 4 below in Indiana, 12 below in Illinois, 3 in Iowa, 14 in Missouri, 20 in Nebraska, 17 in Kansas, 1½ in Kentucky, 5 in Tennessee, 1 in Mississippi, 1 in Louisiana, and 8 in Arkansas.

DROUGHT OF 1876.

A severe drought occurred this year in New England, the Middle Atlantic States, the Ohio Valley, and lower Lake region; it also prevailed quite generally south of the Ohio River and east of the Mississippi. No figures as to precipitation are available.

Only in the following States of the affected region, however, did the corn yield fall below the normal for the forty-year period, 1867-1906:

Average yield of corn in bushels per acre.

State.	1875.	1876.	1877.	Normal.
Maine	30.5	31.0	36.0	33.2
New York	34.0	30.0	32.0	31.0
South Carolina	10.2	8.2	9.0	9.7
Indiana	34.0	30.0	30.0	31.4
Illinois	34.3	25.0	29.0	30.3

DROUGHT OF 1881.

s was a year of serious drought, which affected practically the country east of the Mississippi River and lasted from July to mber.

precipitation at Indianapolis from June 22 to August 30 ty days) was 1½ inches; at Indianapolis, May 15 to June 4 ty-one days), less than ½ inch; at Pittsburg, Pa., from May 7 y 29 (twenty-three days), $\frac{6}{10}$ inch; June 18 to July 15 (twenty- days), 1 inch; August 1 to September 25 (fifty-six days), 1¼ .

Average yield of corn in bushels per acre.

State.	1880.	1881.	1882.	Normal.
	35.4	35.4	29.2	33.2
npshire	38.0	34.2	23.4	35.0
	32.0	35.7	33.9	35.0
setts	33.5	25.1	21.7	34.8
land	30.0	27.0	23.0	[illegible]
cut	29.0	25.5	20.1	32.5
k	34.8	26.4	27.5	31.0
ey	41.0	23.2	28.9	34.2
ania	40.6	25.2	31.3	33.3
	32.0	14.4	18.9	32.8
l	32.0	24.2	25.9	26.7
	25.0	15.0	19.1	19.2
ginia	30.0	22.7	25.4	25.9
rolina	16.4	11.7	14.0	13.5
rolina	9.3	6.7	12.0	9.7
	9.2	8.3	13.3	11.0
	9.4	8.8	9.5	9.9
	37.5	25.4	31.3	33.0
	29.0	21.8	31.3	31.4
	27.2	19.4	23.9	30.3
	40.7	28.0	30.7	30.8
n	33.0	27.6	28.8	31.2
y	29.1	17.0	24.3	26.7
e	22.4	12.4	24.1	22.1
	12.4	9.9	13.9	13.1
pi	14.6	11.0	16.8	15.0
a	19.0	13.0	18.5	16.8
	25.0	11.9	10.3	20.0
s	25.0	14.8	21.6	21.0
	33.0	25.8	25.9	32.4
	28.4	16.5	20.5	28.5
a	31.0	27.4	34.9	30.4
	29.3	18.2	33.7	27.2

every State east of the Mississippi River, with the exception aine, New Hampshire, and Vermont, the yield was lower than e preceding year, 1880, and in nearly every case lower also for the yields for the following year, 1882. This was true also yield as compared with the average for the forty-year period. production of corn in California, Oregon, and Nevada was elow the forty-year average for this year. For the whole coun- e average yield was 18.6 bushels, as compared with 25.5 bushels e forty years—the lowest annual average for the forty-year l, with the exception of the year 1901.

DROUGHTS OF 1886 AND 1887.

6.—Severe drought in Kansas, Nebraska, the Dakotas, Iowa, esota, and western Wisconsin.

7.—This year was also characterized by a severe and prolonged ht over the Ohio Valley, Michigan, Indiana, Illinois, Missouri, Iowa, Nebraska, Kansas, Minnesota, Louisiana, Mississippi, Alabama, and portions of the Middle Atlantic States.

At Iowa City, Iowa, from May 13 to the end of July, 1886, a period of 83 days, 0.95 inch of rain fell, being scarcely 1 per cent of the normal.

"The drought of 1887 was severe in some months, but not consistently so throughout the entire season." (A. J. Henry, in Yearbook, 1897.)

Average yield of corn in bushels per acre.

State.	1885.	1886.	1887.	1888	Normal.
New York[a]	30.7	31.3	33.0	32.4	31.6
New Jersey[a]	32.0	27.2	30.0	32.4	34.3
Pennsylvania[a]	32.5	28.2	32.2	32.5	33.3
Delaware[a]	19.3	16.6	20.0	17.4	22.8
Maryland[a]	22.0	20.9	27.0	23.7	26.7
Virginia[a]	14.9	15.5	17.5	16.3	19.3
West Virginia[a]	23.8	22.8	19.0	23.8	25.9
Ohio[a]	37.1	32.2	26.3	32.5	33.0
Indiana[a]	35.5	31.9	20.0	34.8	31.4
Illinois[a]	31.4	34.5	19.2	35.7	30.3
Michigan[a]	32.7	29.1	22.5	30.0	30.8
Wisconsin[b]	30.1	25.7	25.3	30.6	31.3
Minnesota[a][b]	28.4	20.8	20.8	29.3	30.0
Iowa[a][b]	32.1	25.1	25.5	35.8	32.4
Missouri[a]	31.3	22.2	22.0	31.0	28.5
Dakota[b]	28.9	23.9	33.0	25.5	23.3
Nebraska[a][b]	36.7	27.4	24.1	35.2	30.4
Kansas[a][b]	32.4	21.8	14.6	26.7	27.3
Kentucky[a]	25.5	25.2	18.3	25.8	26.4
Tennessee[a]	21.2	20.7	21.5	20.8	22.1
Alabama[a]	13.4	12.1	13.6	12.7	13.1
Mississippi[a]	13.4	13.1	17.3	14.7	15.0
Louisiana[a]	16.8	15.6	18.0	14.8	16.8

[a] 1887. [b] 1886.

The area of the drought of 1886 probably also extended over the eastern part of the country, although data are lacking on this point. An examination of the foregoing figures, however, shows marked reductions in yield for this year in New Jersey, Pennsylvania, Delaware, Maryland, and Virginia, doubtless due to drought.

The drought of 1887 appears, from a study of the figures, to have been particularly severe in the Ohio Valley and Lake region, and in the central Mississippi and Missouri valleys, where reductions in yield from the normal of from 6 to 13 bushels per acre were noted.

DROUGHT OF 1890.

Beginning with July, a drought of considerable proportions began over the greater part of the States embraced within the corn belt, the amount of precipitation for the month ranging, at many points, from 50 to less than 25 per cent of the average fall. Reports from numerous correspondents over the above-mentioned section indicate that corn was suffering seriously from the prevailing dry weather. The deficiency in rainfall continued during August and into September over a large portion of the more northern and western States of the corn belt.

Average yield of corn in bushels per acre.

State.	1889.	1890.	1891.	Normal.
k.	29.3	28.6	31.8	31.0
y.	30.2	31.3	34.2	34.2
nia.	29.8	27.5	33.3	33.3
	17.5	18.5	22.0	22.8
	20.6	22.5	25.5	26.7
	15.9	17.5	19.7	19.2
ginia.	22.4	20.0	27.3	25.9
	29.6	23.5	32.0	33.0
	29.0	24.7	33.3	31.4
	32.3	26.2	33.5	30.3
	23.5	26.7	29.5	30.8
	32.5	26.0	36.7	32.4
	32.2	25.8	29.9	28.5
	36.5	18.0	35.2	30.4
	35.3	15.6	26.7	27.2
	26.5	22.6	30.0	26.4
o.	22.0	18.8	22.7	22.1
	13.5	10.2	12.7	13.1
d.	14.8	12.5	15.2	15.0
	17.5	16.0	17.3	16.8
	18.3	15.5	19.5	20.0
	20.0	16.7	21.2	21.0
tas.	18.0	13.6	....	23.2
	25.4	18.2	21.5	22.0

le the above figures call attention to the principal States af- by the drought of 1890, with the exception of most of the England States and South Carolina, every State in the Union d reduced yields of corn as compared with the average for the year period, and the average for the whole country fell 5 bushels the normal for the period.

DROUGHTS OF 1894 AND 1895.

fessor Henry, in Climatology of the United States, says:

> greatest drought this country has experienced in the past 100 years, to its intensity and the extent of territory covered, culminated in the Mississippi and Missouri valleys in 1894, and in the Lake region and coast districts in 1895.

DEFICIENT RAINFALL IN 1893.

drought of 1894 was the culmination of a period of deficient rainfall h temperatures that began during the early summer of 1893.

DROUGHT OF 1894.

seasonal rainfall from March 1 to October 1 was largely deficient from ssouri Valley eastward to the Atlantic, including the coast States from rolinas northward. A marked deficiency also occurred in the Central tates and California. The seasonal deficiency in rainfall exceeded 10 in portions of New England and the Middle Atlantic States, eastern , on the central Gulf coast, eastern Tennessee, and from the Ohio Valley ard over the central Mississippi and Missouri valleys. In but one week, pril 30 to September 10, did the rainfall for Huron, S. Dak., which is in ion of severe drought, exceed the weekly average at that station, while nperature was above the normal throughout almost the whole of the eriod. While the actual deficiency in rainfall of 12 inches in central Iowa qualed or exceeded in portions of Florida and eastern Tennessee, in r section of the country east of the Rocky Mountains did the seasonal l form so small a percentage of the normal amount as in Iowa and the eastern portions of Nebraska and South Dakota, where the actual rainfall was only about 50 per cent of the usual seasonal amount, although portions of New England, the Middle Atlantic States, and eastern Tennessee received less than 60 per cent of the seasonal rainfall.

The extensive and protracted drought of July and August was very injurious to crops, most seriously affecting the corn crop, the principal corn-producing States being covered by the region of severest drought.

Rains of April were general deficient in almost all parts of the country, except northern Pacific coast, upper Missouri Valley, and upper Mississippi Valley, although the deficiency east of the Mississippi was not especially marked except along the south Atlantic coast.

In May the greatest deficiency in precipitation, 3 inches or more, occurred in the States of South Dakota, Nebraska, Kansas, Iowa, Illinois, and Missouri.

In June, July, and August the drought continued unabated in these States and extended into the upper Missouri and Ohio valleys, the Lake region, and portions of New England and Middle Atlantic States. The months of July and August were exceptionally dry in the Ohio Valley, Lake region, Missouri Valley, and middle and upper portions of the Mississippi Valley. Over this great area less than 2 inches of rain, on the average, fell in two months. In Iowa the average precipitation for July was 0.6 inch—3.7 inches below the normal; in August, 1.6 inches—2 inches below normal. The rainfall of September was not far from normal in the drought-stricken region of the Middle West, but continued below normal in a number of other districts.

DROUGHT OF 1895.

The shortage of rainfall during 1895 was almost as great and as widespread as in the previous year, but the region of greatest intensity was shifted from the middle Mississippi Valley eastward to the Lake region and upper Ohio Valley.[a]

EFFECT OF DROUGHT ON CROP PRODUCTION.

Notwithstanding the widespread deficiency in annual precipitation, the total crop production in the United States for both 1894 and 1895 did not fall greatly below a normal year, except that the corn crop for 1894 and the hay crop for 1895 were both short crops. The average yield per acre for corn in 1894 was 19.4 bushels, as against an average of 23.5 bushels for ten years, 1892-1901.

The corn yield for 1894 was generally below the normal, and was much below it in Kansas, Iowa, and Nebraska—in the two last the lowest recorded for those States. In both States the precipitation for the summer was also the least recorded, while in July the average rainfall for Iowa and eastern Kansas and Nebraska was only about one-half inch. In Iowa, the month of July, 1894, was the driest ever experienced.

According to Mr. J. Warren Smith,[b] of the United States Weather Bureau, the precipitation for 1895 in the great corn States of the Middle West was abundant, and excessive in Missouri and Kansas. An examination of the available statistics fails to show any marked decline in corn yields in 1895; in fact, the general average for the whole country was above the normal.

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[a] See Climatology of the United States, by A. J. Henry, p. 52. Statistics show, however, that, even in the Lake region and Ohio Valley, the yields were lower for 1894 than for 1895; in fact, the general average for the whole country in 1895 is above the normal.

[b] See Relation of Precipitation to Yield of Corn, by J. Warren Smith, Yearbook, Dept. of Agr., 1903.

DROUGHTS OF 1894 AND 1895.

Average yield of corn in bushels per acre.

State.	1892.	1893.[a]	1894.	1895.	1896.	Normal.
Maine	35.5	30.3	39.9	42.0	37.0	33.2
New Hampshire	37.8	31.7	34.3	40.2	42.0	35.0
Vermont	38.0	32.4	40.8	45.6	41.0	35.0
Massachusetts	38.7	33.5	34.5	43.9	42.0	34.8
Rhode Island	33.4	24.4	31.4	30.9	34.0	30.4
Connecticut	34.5	28.2	31.0	37.9	38.0	32.5
New York	33.0	29.5	28.2	35.6	34.0	31.0
New Jersey	31.6	25.9	33.1	33.0	33.0	34.2
Pennsylvania	30.5	24.5	32.0	33.5	40.0	33.3
Delaware	18.7	24.6	22.0	21.0	22.0	22.8
Maryland	20.6	24.2	22.9	26.8	32.0	26.7
Virginia	15.3	18.9	19.1	18.6	21.5	19.2
North Carolina	10.2	12.3	13.4	14.5	12.0	13.5
South Carolina	10.5	7.7	11.2	11.1	9.0	9.7
Georgia	11.2	11.1	11.7	13.3	11.0	11.0
Florida	9.0	9.7	10.1	11.2	10.0	9.9
Alabama	12.2	11.5	13.7	15.9	12.5	13.1
Mississippi	13.7	13.1	17.2	15.8	13.5	15.0
Louisiana	14.8	14.2	16.2	18.1	13.0	16.8
Texas	21.4	17.6	19.0	26.4	9.5	20.0
West Virginia	22.5	21.7	18.5	24.2	30.0	25.9
Ohio	29.4	23.8	26.3	32.6	41.0	33.0
Indiana	29.3	24.7	28.9	32.8	36.0	31.4
Illinois	26.2	25.7	28.8	37.4	40.5	30.3
Kentucky	23.3	23.5	23.0	31.2	28.0	26.4
Tennessee	20.3	21.3	21.9	25.0	23.0	22.1
Arkansas	17.5	16.2	19.2	21.5	13.5	21.0
Michigan	25.0	23.7	23.2	32.8	38.0	30.8
Wisconsin	27.3	29.8	20.7	31.8	37.0	31.2
Minnesota	27.0	28.3	18.4	31.2	30.5	30.0
Missouri	27.7	27.9	22.0	36.0	27.0	28.5
Iowa	28.3	33.9	15.0	35.1	39.0	32.4
Kansas	24.5	21.3	11.2	24.3	28.0	27.2
Nebraska	28.2	25.2	6.0	16.1	37.5	30.4
North Dakota	21.4	20.7	19.2	21.3	35.0	22.1
South Dakota	22.3	23.7	4.2	11.1	26.0	23.5
Colorado	22.3	16.5	19.7	20.7	16.0	22.0
Montana	19.4	27.5	32.7	25.0	26.0	24.3
Wyoming	18.5	18.5	30.0	27.5	25.0	24.6
Utah	18.1	21.5	24.4	20.3	25.0	22.5
Idaho	16.8	19.5	28.6	30.7	....	25.1
Washington	18.0	21.3	20.8	17.1	14.0	21.6
Oregon	21.5	24.7	25.4	26.4	22.0	25.5
California	30.3	37.1	19.3	34.5	37.0	31.4
Arizona	17.4	17.8	18.6	26.0	....	21.6
New Mexico	20.0	25.3	19.1	27.2	....	22.0

[a] The drought of 1894 was the culmination of a period of deficient rainfall and high temperatures that began during the early summer of 1893.

WEATHER CONDITIONS FOR 1896 AND 1897.

The corn crop of 1896 was above the average for the country for the 40-year period. Available data show that for the greater part of the corn belt abundant rains prevailed, with the exception that in the Western Gulf States the precipitation for the whole year was 12.5 inches below the normal rainfall, and in the South Atlantic States it was 10.7 inches below.[a]

In 1897 droughty conditions prevailed over portions of Texas, Arkansas, Missouri, Tennessee, Kansas, Louisiana, Virginia, Kentucky, and North Carolina. Cool weather and frosts during the early summer seriously injured corn in Wisconsin, Minnesota, and North Dakota.

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[a] See Rainfall of the Crop Season, by A. J. Henry, Yearbook, Dept. of Agr., 1897, p. 616.

Average yield of corn in bushels per acre.

State.	1896.	1897.	Normal.
Virginia	21.5	18.0	19.2
North Carolina	12.0	13.0	13.5
South Carolina	9.0	9.0	9.7
Florida	10.0	8.0	9.9
Louisiana	13.0	17.0	16.8
Texas	9.5	18.5	20.6
Arkansas	13.5	16.0	21.0
Kentucky	28.0	23.0	26.4
Tennessee	23.0	21.0	22.1
Kansas	28.0	18.0	27.2
Missouri	27.0	26.0	28.5
Wisconsin	37.0	32.0	31.2
Minnesota	30.5	26.0	30.0
North Dakota	35.0	17.0	22.1

WEATHER CONDITIONS FOR 1898.

On the whole the season was generally favorable for corn.

Severe local droughts occurred in California from about April 1 to May 15 (interrupted with slight rainfall in the southern portion during the week ending May 2). Excessive heat and drought occurred during the latter half of August in parts of Nebraska, Kansas, Missouri, and generally in the States of the eastern Rocky Mountain slope.

LOCAL DROUGHT OF 1899.

Season generally very favorable for corn. Late corn was injured considerably by drought, which prevailed from about August 10 for two weeks in parts of Missouri, Kansas, and Nebraska, and from about August 20 for three to four weeks over the greater part of Oklahoma, Texas, southern Missouri, and States of the central Mississippi and Ohio valleys.

A glance at the following figures will show the effect of the drought:

Average yield of corn in bushels per acre.

State.	1899.	Normal.	State.	1899.	Normal
Kentucky	21.0	26.4	Missouri	26.0	28.5
Tennessee	20.0	22.1	Kansas	27.0	27.2
Arkansas	20.0	21.0	Nebraska	28.0	30.4
Oklahoma	19.0	23.5	Michigan	25.0	30.8
Texas	18.0	20.0	Iowa	31.0	32.4

LOCAL DROUGHT OF 1900.

The Weather Bureau reports the year for the country as a whole as a good corn year.

A condition of drought occurred from about May 7 to July 1, with intermittent periods of very slight rainfall, in portions of the upper Missouri Valley. The droughty conditions were reported to be especially severe in eastern Montana and North Dakota, and the following figures, so far as corn crop is concerned, show the influence of the dry weather in these States:

Average yield of corn in bushels per acre.

State.	1900.	Normal.
North Dakota	16.0	22.6
Montana	15.0	25.0

DROUGHT OF 1901.

A severe drought occurred in 1901, which cut the corn crop very short.

This drought prevailed from June 24 to July 29—thirty-six days—over the States of the central valleys and middle Rocky Mountain region, and also in lesser degree in the Lake region, the Ohio Valley, and Tennessee.

After July 29 rains occurred over the larger part of the drought area of the Mississippi and upper Missouri valleys, but drought continued about a week longer, becoming very serious in the Ohio Valley and Tennessee.

Average yield of corn in bushels per acre.

State.	1900.	1901.	1902.	Normal.
West Virginia	27.0	23.0	26.5	25.9
Ohio	37.0	26.1	38.0	33.0
Indiana	38.0	19.8	37.9	31.4
Illinois	37.0	21.4	38.7	30.3
Wisconsin	40.0	27.4	28.2	31.2
Minnesota	33.0	26.3	22.8	30.0
Iowa	38.0	25.0	32.0	32.4
Missouri	28.0	10.1	39.0	28.5
South Dakota	27.0	21.0	18.9	23.5
Nebraska	26.0	14.1	32.3	30.4
Kansas	19.0	7.8	29.9	27.2
Colorado	19.0	17.1	16.5	22.0
Kentucky	26.0	15.6	27.0	26.4
Tennessee	20.0	14.2	21.9	22.1
Mississippi	11.0	10.9	11.5	15.0
Louisiana	17.0	13.7	12.5	16.8
Texas	18.0	11.6	8.1	20.0
Oklahoma	26.0	7.3	25.8	23.5
Arkansas	19.0	8.1	21.3	21.0
Indian Territory		12.0	24.9	27.2

The average yield for the whole country this year was only 16.7 bushels per acre, which is the lowest average yield reported for the United States since 1867.

WEATHER CONDITIONS FOR 1902.

A drought of several weeks' duration prevailed over the Gulf States during June and July. A severe drought also occurred over the central and southern Rocky Mountain districts from July 25 to September 20.

The season was characterized, however, in the greater portion of the corn belt by excessive rains and unusually cold weather, especially over the central and northern portions of the belt and in the New England States. Cold weather also prevailed in the northern and central Rocky Mountain regions. Killing frosts occurred in New England and in the Lake regions in June; late corn was seriously damaged by heavy frosts over the northern part of the corn belt, especially west of the Mississippi River, frost with ice occurring as early as August 29 in exposed places in the northern Rocky Mountain region.

While the yield for the entire country was slightly above the normal, it may be seen from the following figures that the cold weather was responsible for very reduced yields of corn in a number of States. In the Gulf States, however, i. e., Alabama, Mississippi, Louisiana, and Texas, the low yields were undoubtedly due to drought.

Average yield of corn in bushels per acre.

State.	1902.	Normal.
Maine	21.7	33.2
New Hampshire	23.3	35.0
Vermont	21.8	35.6
Massachusetts	31.3	34.3
Rhode Island	28.4	30.4
Connecticut	31.5	32.5
New York	25.0	31.0
Michigan	26.4	30.8
Wisconsin	28.2	31.2
Minnesota	22.8	30.0
Iowa	32.0	32.4
North Dakota	19.4	22.1
South Dakota	18.9	23.5
Colorado	16.5	22.0
Wyoming	19.8	24.6
Alabama	8.4	12.1
Mississippi	11.5	15.0
Louisiana	12.5	16.8
Texas	8.1	20.0

WEATHER CONDITIONS FOR 1903.

May 4.—This week was unseasonably cool over much the greater part of the country, the minimum temperatures on April 30 and May 1 and 2 being the lowest recorded in the last thirty years at nearly all Weather Bureau stations from the central and west Gulf coasts to the upper Missouri Valley, and also at a number of stations in the central Mississippi and Ohio valleys, Lake region, and New England. Unseasonably low temperatures checked the growth of all vegetation, and heavy frosts and freezes caused much damage. * * * The early planted corn was extensively killed by the freeze during the latter part of the week in Missouri, Kansas, Oklahoma, and Texas, and the crop suffered from cold weather throughout the Southern States.

After the early freeze corn was generally replanted in the Southern States and Gulf States, and the remainder of the season was generally favorable for corn in these sections, where average crops were obtained. Replanting was also necessary in many other sections where early corn had been planted.

The whole crop season was abnormally cool over the Missouri and upper Mississippi valleys, and much corn was seriously damaged by excessive rains.

Drought occurred from May 15 to about June 15 in the northern portion of the Middle Atlantic States and in the New England States. The droughty conditions in the Middle Atlantic States were reported to be especially severe in eastern New York.

Average yield of corn in bushels per acre.

State.	1902.	1903.	1904.	Normal.
Maine	21.7	30.2	39.7	33.2
New Hampshire	23.3	21.0	27.3	35.0
Vermont	21.8	23.4	35.9	35.0
Massachusetts	31.3	24.0	36.0	34.8
Rhode Island	28.4	30.1	34.1	30.4
Connecticut	31.5	22.4	38.9	32.5
New York	25.0	25.0	27.3	31.0
New Jersey	34.5	24.0	38.0	34.2
Pennsylvania	36.1	31.2	34.0	33.3
West Virginia	26.5	22.6	25.3	25.9
Wisconsin	28.2	29.3	29.7	31.2
Minnesota	22.8	28.3	26.9	30.0
Iowa	32.0	28.0	32.6	32.4
Nebraska	32.3	26.0	32.8	30.4
Kansas	29.9	25.6	20.9	27.2

WEATHER CONDITIONS FOR 1904.

The season was generally cool and rainy over the greater part of the corn belt.

A three-weeks' drought prevailed during May over the east Gulf States, but was not serious enough to cause any reduction in the yield of corn, good average crops being secured in these States.

The cool weather, rains, lack of sunshine, and lack of cultivation were probably responsible for a decline in yield in several of the States.

Average yield of corn in bushels per acre.

State.	1903.	1904.	1905.	Normal.
New York	25.0	27.3	31.5	31.0
Michigan	33.5	28.6	34.0	30.8
Minnesota	28.3	26.9	32.5	30.0
Missouri	32.4	26.2	33.8	28.5
North Dakota	25.2	21.2	27.5	22.1
Kansas	25.6	20.9	27.7	27.2
Montana	24.1	22.2	19.4	24.3

WEATHER CONDITIONS FOR 1905.

The season in general was very favorable for corn.

Planting was delayed by cold weather and rain, which continued as late as June 1 and was general throughout the corn belt. Germination was slow and corn suffered from lack of cultivation.

Some damage was done to corn as a result of rains and high winds in the lower Missouri Valley, especially in Kansas and Missouri. In Missouri corn was extensively blown down, but the yield was heavy notwithstanding this. Wind also did considerable injury in Nebraska, Arkansas, and Ohio.

No serious droughts.

The yield was about average in all States except Montana, Oregon, Louisiana, and Arkansas; in many States considerably above the average.

WEATHER CONDITIONS FOR 1906.

The conditions over the country were generally favorable for corn, but local droughts prevailed over portions of the West Gulf States, the lower Mississippi Valley, and portions of Missouri and Tennessee during the week ending May 14 and for two weeks in June.

With the exception of Montana, however, every State in the Union yielded crops above the normal for the forty-year period, the average for the whole country being higher than for any year since 1872.

STATISTICS OF CORN.

Average yield of corn in the United States, in bushels per acre, for the forty years 1867–1906.

(Marked decreases in yield, as compared with the average for the forty-year period, are indicated by italic and boldface figures. Italic figures show decreased yields due principally to severe local or sectional droughts. Boldface figures show the low yields due to the great general droughts.)

Year.	Maine.	New Hampshire.	Vermont.	Massachusetts.	Rhode Island.	Connecticut.	New York.	New Jersey.	Pennsylvania.	Delaware.	Maryland.	Virginia.	West Virginia.	North Carolina.	South Carolina.	Georgia.	Florida.
1867	33.4	35.5	36.2	35.7	25.7	33.0	30.4	33.1	32.0	*16.8*	28.4	20.9	29.7	11.6	9.6	13.1	11.8
1868	29.8	35.0	38.5	37.0	27.0	34.0	32.0	37.5	35.0	25.0	27.7	19.3	35.0	14.3	10.2	12.7	10.5
1869	24.3	30.0	34.0	34.2	25.2	31.2	27.1	30.8	31.4	18.0	20.2	*15.5*	27.8	14.8	11.6	11.0	11.2
1870	33.0	36.5	39.6	33.0	26.0	*26.4*	34.0	33.0	35.8	25.0	22.5	20.0	30.4	14.6	8.9	13.5	10.8
1871	27.2	35.7	35.6	34.3	27.3	31.4	33.0	36.0	35.5	22.0	23.6	22.6	27.6	14.0	10.0	10.3	10.7
1872	33.5	38.2	39.0	34.0	30.0	31.2	37.5	39.5	39.0	20.0	23.0	21.0	28.5	16.0	10.5	12.5	9.6
1873	24.0	37.5	31.0	35.0	28.7	30.0	31.0	36.0	35.1	19.0	21.4	19.0	29.0	14.2	9.5	12.3	10.4
1874	24.6	36.4	36.1	32.0	24.3	30.0	30.0	35.0	33.2	18.0	20.5	20.0	26.5	16.4	11.0	11.1	10.6
1875	30.5	38.0	37.0	37.0	27.5	29.0	34.0	41.0	40.0	26.0	30.0	22.0	29.1	15.0	10.2	10.0	10.0
1876	31.0	42.0	39.0	35.0	35.0	32.5	30.0	36.0	35.0	30.0	29.0	20.0	28.2	14.6	8.2	11.0	10.0
1877	36.0	42.5	39.0	34.7	33.0	29.0	32.0	36.4	33.0	22.0	28.0	19.6	25.5	14.0	9.0	10.5	12.9
1878	40.0	39.0	41.0	36.0	32.0	29.6	36.0	36.0	35.0	25.0	23.5	17.5	27.2	13.6	9.3	11.0	9.0
1879	30.0	32.5	36.0	36.0	32.0	29.0	33.0	34.0	35.0	27.0	30.6	19.0	31.0	15.0	*7.5*	9.3	*8.5*
1880	35.4	38.0	32.0	33.5	30.0	29.0	34.8	41.0	40.6	32.0	32.0	25.0	30.0	16.4	9.3	9.2	9.4
1881	34.0	34.2	35.7	25.1	27.0	**25.5**	**26.4**	**28.2**	**25.2**	**14.4**	24.2	**15.0**	22.7	11.7	**6.7**	**8.3**	**8.2**
1882	29.2	*23.4*	33.9	*21.7*	*23.0*	*20.1*	27.5	28.9	31.3	18.9	25.9	19.1	25.4	14.0	12.0	13.3	9.5
1883	35.0	36.0	31.0	35.0	32.0	30.0	*23.0*	28.0	27.0	18.0	23.5	*14.0*	24.3	11.5	*8.0*	8.7	*8.5*
1884	34.7	33.2	33.2	34.0	30.4	31.0	30.1	32.0	31.0	18.5	21.8	15.2	*20.0*	12.5	9.2	10.8	9.5
1885	32.3	33.8	32.2	34.0	33.5	35.0	30.7	32.0	32.5	19.3	22.0	*14.9*	23.8	*9.9*	9.0	11.3	9.0
1886	31.4	35.4	32.8	32.7	31.5	34.3	31.3	27.2	28.2	*16.6*	20.9	15.5	22.8	*10.5*	9.1	10.8	10.4
1887	35.2	34.3	35.5	35.4	32.0	34.0	33.0	30.0	32.2	20.0	27.0	17.5	**19.0**	13.4	10.0	11.0	10.6
1888	*19.9*	*22.6*	*24.3*	30.1	30.4	31.2	32.4	32.4	32.5	*17.4*	23.7	16.3	23.8	*10.6*	8.7	9.6	9.8
1889	36.0	36.5	35.0	34.3	31.3	31.0	29.3	30.2	29.8	*17.5*	20.6	15.9	22.4	12.0	11.5	11.2	10.7
1890	36.2	36.5	33.5	34.5	32.7	35.7	26.6	31.3	27.5	18.5	22.5	17.5	**20.0**	13.3	10.2	10.5	9.3
1891	37.5	35.8	37.2	39.5	34.5	36.0	31.8	34.2	33.3	22.0	25.5	19.7	27.3	14.1	11.6	12.2	11.0
1892	35.5	37.8	38.0	38.7	33.4	34.5	33.0	31.6	30.5	18.7	20.6	15.3	22.5	*10.2*	10.5	11.2	9.0
1893	30.3	31.7	32.4	33.5	*24.4*	28.2	29.5	*25.9*	*24.5*	24.6	24.2	18.9	21.7	12.3	7.7	11.1	9.7
1894	39.9	34.3	40.8	34.5	31.4	31.0	28.2	33.1	32.0	22.0	22.9	19.1	**18.5**	13.4	11.2	11.7	10.1
1895	42.0	40.2	45.6	43.9	30.9	37.9	35.6	33.0	33.5	21.0	26.8	18.6	24.2	14.5	11.1	13.0	11.2
1896	37.0	42.0	41.0	43.0	34.0	38.0	34.0	33.0	40.0	22.0	32.0	21.5	30.0	12.0	9.0	11.0	10.0
1897	37.0	34.0	35.0	32.5	31.0	31.5	31.0	31.5	36.0	29 0	33.0	18.0	24.5	13.0	9.0	11.0	*8.0*
1898	40.0	41.0	43.0	40.0	34.0	37.0	33.0	37.0	37.0	25.0	31.0	22.0	29.0	14.0	10.0	9.0	9.0
1899	36.0	39.0	36.0	36.0	31.0	39.0	31.0	39.0	32.0	22.0	32.0	20.0	26.0	13.0	9.0	10.0	10.0
1900	36.0	37.0	40.0	38.0	32.0	38.0	32.0	33.0	*25.0*	24.0	26.0	16.0	27.0	12.0	7.0	10.0	*8.0*
1901	39.4	38.5	40.0	40.5	32.1	39.0	33.0	36.9	35.0	30.0	34.2	22.2	23.0	12.0	**6.9**	10.0	9.0
1902	*21.7*	*23.3*	*21.8*	31.3	28.4	31.5	*25.0*	34.5	36.1	28.0	32.4	22.0	26.5	13.9	10.4	9.0	8.6
1903	30.2	*21.9*	*23.4*	*24.0*	30.1	*22.4*	*25.0*	*24.0*	31.2	27.5	28.7	21.8	22.6	14.7	10.3	11.7	9.9
1904	39.7	27.3	35.9	36.0	34.1	38.9	27.3	38.0	34.0	30.4	33.4	23.3	25.3	15.2	12.4	11.9	10.7
1905	34.3	37.0	34.7	37.5	32.5	42.7	31.5	35.8	38.9	30.4	36.9	23.4	29.8	13.9	10.9	11.0	10.1
1906	37.0	37.5	35.5	39.7	33.1	40.0	34.9	36.3	40.2	30.0	35.0	24.3	30.3	15.3	12.2	12.0	11.0
Average	33.2	35.0	35.0	34.8	30.4	32.5	31.0	34.2	33.3	22.8	26.7	19.2	25.9	13.5	9.7	11.0	9.9

Average yield of corn in the United States, etc.—Continued.

Year	Ohio.	Indiana.	Illinois.	Michigan.	Wisconsin.	Minnesota.	Iowa.	Missouri	Nebraska.	Kansas.	Dakota.	North Dakota.	South Dakota.	Kentucky.	Tennessee.	Alabama.	Mississippi.
1867	28.7	29.2	*23.5*	31.4	33.6	30.0	33.5	27.2	36.0	38.6	......	......	......	24.7	23.7	16.2	15.7
1868	34.0	34.0	34.2	33.0	33.0	33.5	37.0	30.3	*22.9*	*18.0*	......	......	......	32.7	25.3	*10.8*	17.1
1869	30.1	*23.2*	*23.2*	28.9	26.4	29.1	33.2	30.6	42.2	48.4	......	......	......	25.0	20.0	15.0	17.5
1870	39.0	39.5	35.2	37.0	38.0	33.0	32.0	31.4	29.9	28.0	......	......	......	32.1	25.8	17.5	16.5
1871	38.5	35.7	38.3	32.4	37.7	37.3	42.5	38.0	41.5	40.0	......	......	......	27.3	23.0	14.5	14.0
1872	39.5	38.7	39.8	36.0	38.0	35.2	39.8	37.0	37.8	38.5	......	......	......	31.2	23.5	17.6	17.5
1873	35.0	25.6	*21.0*	31.0	30.0	31.5	29.0	*23.5*	35.0	39.1	......	......	......	29.5	22.5	14.5	15.5
1874	36.0	27.0	**18.0**	27.0	28.2	31.0	29.2	**16.0**	**10.0**	**10.5**	......	......	......	25.0	**16.8**	12.3	13.8
1875	34.5	34.0	34.3	33.0	*21.0*	29.2	35.0	36.6	40.0	40.0	......	......	......	33.3	26.5	12.6	18.0
1876	36.7	30.0	*25.0*	29.0	34.0	*25.4*	30.0	27.8	30.0	43.5	......	......	......	33.5	24.5	13.0	15.0
1877	31.5	30.0	29.0	31.0	28.0	29.0	32.5	29.0	38.0	36.5	......	......	......	30.3	25.0	12.0	15.0
1878	34.9	32.8	27.1	37.4	37.5	38.1	37.4	26.2	42.0	33.9	......	......	......	22.7	19.3	12.0	13.0
1879	35.0	33.0	35.0	37.0	39.0	35.0	38.0	37.0	41.0	33.0	......	......	......	32.0	25.0	13.0	16.0
1880	37.5	29.0	27.2	40.7	33.0	35.0	38.0	28.4	31.0	29.3	......	......	......	29.1	22.4	12.4	14.6
1881	**25.4**	**21.8**	**19.4**	28.0	27.6	32.0	**25.8**	**16.5**	27.4	**18.2**	......	......	......	**17.0**	**12.4**	**9.9**	**11.0**
1882	31.3	31.3	*23.0*	30.7	28.8	32.0	*25.9*	29.5	34.9	33.7	25.0	......	......	24.3	24.1	13.9	16.8
1883	*26.1*	27.0	*25.0*	*23.5*	*21.0*	*20.8*	*24.5*	27.5	36.0	36.7	*18.2*	......	......	24.0	20.0	11.5	13.5
1884	30.0	29.0	30.0	28.0	*24.6*	33.5	34.5	33.0	37.7	36.9	30.0	......	......	22.1	20.3	13.0	13.5
1885	37.1	35.5	31.4	32.7	30.1	28.4	32.1	31.3	36.7	32.4	28.9	......	......	25.5	21.2	13.4	13.4
1886	32.2	31.9	*24.5*	29.1	*25.7*	29.8	*25.1*	*22.2*	27.4	*21.8*	23.9	......	......	25.2	20.7	12.1	13.1
1887	**26.8**	**20.0**	**19.2**	**22.5**	**25.8**	29.8	**25.5**	**22.0**	**24.1**	**14.6**	33.0	......	......	**18.8**	21.5	13.6	17.3
1888	32.5	34.8	35.7	30.0	30.6	29.3	35.8	31.0	35.2	26.7	25.5	......	......	25.8	20.8	12.7	14.7
1889	29.6	29.0	32.3	*23.5*	26.3	28.5	39.5	32.2	36.5	35.3	*18.0*	......	......	26.5	22.0	13.5	14.8
1890	**23.5**	**24.7**	26.2	26.7	30.0	27.7	**26.0**	25.8	**18.0**	**15.6**	**13.6**	......	......	**22.6**	**18.8**	**10.2**	12.5
1891	32.0	33.3	33.5	29.5	26.7	26.5	36.7	29.9	35.2	26.7	......	18.0	22.5	30.0	22.7	12.7	15.2
1892	29.4	29.3	26.2	25.0	27.3	27.0	28.3	27.7	28.2	24.5	......	21.4	22.3	23.3	20.3	12.2	13.7
1893	*23.8*	*24.7*	25.7	*23.7*	29.8	28.3	33.9	27.9	25.2	*21.3*	......	20.7	23.7	23.5	21.3	11.5	13.1
1894	**26.3**	28.9	28.8	**23.2**	**20.7**	**18.4**	**15.0**	**22.0**	**6.0**	**11.2**	......	19.2	**4.2**	23.0	21.9	13.7	17.2
1895	32.6	32.8	37.4	33.8	31.8	31.2	35.1	36.0	*10.1*	24.3	......	21.3	11.1	31.2	25.0	15.9	15.8
1896	41.0	35.0	40.5	38.0	37.0	30.5	39.0	27.0	37.5	28.0	......	35.0	26.0	28.0	23.0	12.5	13.5
1897	32.5	30.0	32.5	31.5	33.0	26.0	29.0	26.0	30.0	*18.0*	......	17.0	24.0	23.0	21.0	12.0	14.5
1898	37.0	36.0	30.0	34.0	35.0	32.0	35.0	26.0	*21.0*	*16.0*	......	19.0	28.0	31.0	26.0	15.0	18.0
1899	36.0	38.0	36.0	25.0	35.0	33.0	31.0	26.0	28.0	27.0	......	23.0	26.0	*21.0*	20.0	12.0	16.0
1900	37.0	38.0	37.0	36.0	40.0	33.0	38.0	28.0	26.0	*19.0*	......	*16.0*	27.0	26.0	20.0	11.0	*11.0*
1901	**26.1**	**19.8**	**21.4**	34.5	*27.4*	26.3	**25.0**	**10.1**	**14.1**	**7.8**	......	22.6	21.0	**15.6**	**14.2**	**10.9**	**10.9**
1902	38.0	37.9	38.7	*26.4*	28.2	*22.8*	32.0	30.0	32.3	29.9	......	19.4	18.9	27.0	21.9	*8.4*	*11.5*
1903	29.6	33.2	32.2	33.5	29.3	28.3	28.0	32.4	26.0	25.6	......	25.2	27.2	26.6	23.5	14.8	18.4
1904	32.5	31.5	36.5	28.6	29.7	26.9	32.6	26.2	32.8	*20.9*	......	21.2	28.1	26.9	25.0	15.0	19.1
1905	37.8	40.7	39.8	34.0	37.6	32.5	34.8	33.8	32.8	27.7	......	27.5	31.8	29.7	24.6	14.8	14.3
1906	42.6	39.6	36.1	37.0	41.2	33.6	39.5	32.3	34.1	28.9	......	27.8	33.5	33.0	28.1	16.0	18.5
Average	33.0	31.4	30.3	30.8	31.2	30.0	32.4	28.5	30.4	27.2	24.0	22.1	23.5	26.4	22.1	13.1	15.0

***Average yield of corn in the United States, etc.*—Continued.**

Year.	Louisiana.	Texas.	Arkansas.	Indian Territory.	Oklahoma.	California.	Oregon.	Washington.	Colorado.	Wyoming.	Montana.	Utah.	Idaho.	New Mexico.	Arizona.	Nevada.	United States.
1867	15.6	28.2	26.5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23.6
1868	22.0	25.0	30.5	.....	.....	45.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.0
1869	25.0	29.0	28.0	.....	.....	41.4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	23.6
1870	22.5	26.5	31.8	.....	.....	35.6	29.7	.....	.....	.....	.....	.....	.....	.....	.....	35.0	28.3
1871	14.4	19.0	26.7	.....	.....	38.0	26.6	.....	.....	.....	.....	.....	.....	.....	.....	32.0	29.1
1872	18.5	25.3	23.5	.....	.....	35.0	28.0	.....	.....	.....	.....	.....	.....	.....	.....	33.0	30.8
1873	16.5	19.0	23.5	.....	.....	41.0	30.0	.....	.....	.....	.....	.....	.....	.....	.....	30.0	23.2
1874	15.5	19.0	**12.6**	.....	.....	29.0	30.5	.....	.....	.....	.....	.....	.....	.....	.....	29.0	**20.7**
1875	15.5	20.0	30.0	.....	.....	36.3	26.5	.....	.....	.....	.....	.....	.....	.....	.....	29.0	29.5
1876	17.2	25.0	24.0	.....	.....	33.0	30.0	.....	.....	.....	.....	.....	.....	.....	.....	28.0	26.2
1877	17.0	24.0	24.0	.....	.....	30.0	26.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.7
1878	19.9	26.0	24.0	.....	.....	34.5	33.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	26.9
1879	15.0	*13.0*	24.0	.....	.....	28.0	32.0	.....	.....	.....	.....	.....	.....	.....	.....	.....	29.2
1880	19.0	25.0	25.0	.....	.....	32.0	23.3	.....	18.5	.....	.....	.....	.....	.....	.....	*20.0*	27.6
1881	**13.0**	**11.9**	**14.8**	.....	.....	27.2	**20.2**	.....	25.5	.....	.....	.....	.....	.....	.....	24.8	**18.6**
1882	18.5	19.3	21.6	.....	.....	28.3	23.9	23.4	20.0	.....	36.6	20.8	28.5	21.2	21.0	*21.7*	24.6
1883	14.2	17.5	17.5	.....	.....	24.5	23.5	23.0	25.0	.....	20.0	21.0	20.0	20.0	20.0	24.9	22.7
1884	*12.7*	16.1	18.5	.....	.....	30.0	27.8	32.7	28.1	.....	24.9	21.7	20.0	20.1	21.2	25.3	25.8
1885	16.8	20.6	20.2	.....	.....	*24.7*	22.8	26.4	34.5	.....	25.0	29.8	21.5	20.5	22.1	24.8	26.5
1886	15.6	*15.7*	20.4	.....	.....	27.2	26.7	26.1	31.5	.....	24.7	20.0	21.5	20.0	22.2	25.7	22.0
1887	18.0	17.0	20.0	.....	.....	30.0	27.3	21.9	30.0	.....	27.5	21.6	28.2	19.0	19.0	27.8	**20.1**
1888	14.8	19.2	19.5	.....	.....	27.8	22.5	20.0	22.6	.....	.....	*14.5*	.....	18.5	.....	.....	26.3
1889	17.5	18.3	20.0	.....	.....	28.2	*20.0*	.....	25.4	.....	.....	18.3	.....	20.0	.....	.....	27.0
1890	16.0	**15.5**	**16.7**	.....	.....	27.5	21.6	.....	18.2	.....	.....	21.0	.....	20.0	.....	.....	**20.7**
1891	17.3	19.5	21.2	.....	.....	34.5	27.0	.....	21.5	.....	.....	19.0	.....	18.3	.....	.....	27.0
1892	14.8	21.4	17.5	.....	.....	30.3	21.5	18.0	22.3	*18.5*	*19.4*	18.1	*16.8*	20.0	17.4	.....	23.1
1893	14.2	17.6	*16.9*	.....	.....	37.1	24.7	21.3	*16.5*	*18.5*	27.5	21.5	19.5	25.3	17.8	.....	22.5
1894	16.2	19.0	19.2	.....	.....	**19.3**	25.4	20.8	19.7	30.0	32.7	24.4	28.6	19.1	18.6	.....	**19.4**
1895	18.1	26.4	21.5	.....	.....	34.5	26.4	17.1	20.7	27.5	25.0	20.3	30.7	27.2	26.0	.....	26.2
1896	13.0	*9.5*	*13.5*	.....	.....	37.0	22.0	*14.0*	*16.0*	25.0	26.0	25.0	.....	*16.0*	.....	.....	28.2
1897	17.0	18.5	*16.0*	.....	.....	31.5	25.0	18.0	19.0	*12.0*	*18.0*	22.0	.....	27.0	.....	.....	23.8
1898	18.0	25.0	20.0	.....	.....	26.0	24.0	*12.0*	18.0	*16.0*	28.0	21.0	.....	21.0	.....	.....	24.8
1899	18.0	18.0	20.0	.....	19.0	27.0	22.0	23.0	*17.0*	22.0	23.0	20.0	.....	20.0	.....	.....	25.3
1900	17.0	18.0	19.0	.....	26.0	25.0	23.0	20.0	19.0	34.0	*15.0*	20.0	.....	22.0	.....	.....	25.3
1901	13.7	**11.6**	**8.1**	**12.0**	**7.3**	31.0	**20.8**	17.5	**17.1**	30.5	25.0	19.4	23.0	31.6	18.0	.....	**16.7**
1902	*12.5*	*8.1*	21.3	24.9	25.8	30.5	23.4	23.0	*16.5*	19.8	22.0	20.1	24.7	22.0	20.2	.....	26.8
1903	20.6	24.2	20.9	27.7	23.3	30.7	25.8	23.1	19.8	19.4	24.1	21.4	34.5	24.0	22.4	.....	25.5
1904	19.9	22.6	21.6	32.4	28.1	28.6	28.8	24.7	20.5	32.5	22.2	33.2	29.3	22.7	23.8	.....	26.8
1905	13.7	21.3	17.3	32.7	25.3	32.0	23.0	24.2	23.8	26.9	*19.4*	36.2	27.2	25.3	27.0	.....	28.8
1906	17.2	22.5	23.6	33.6	32.9	34.9	27.6	25.2	27.9	27.0	23.4	32.0	28.3	29.4	29.5	.....	30.3
Average	16.8	20.0	21.0	27.2	23.5	31.4	25.5	21.6	22.0	24.6	24.3	22.5	25.1	22.0	21.6	27.4	25.2

The principal drought years covered by the above table, where the condition of minimum rainfall was more or less general throughout the United States, were 1874, 1881, 1887, 1890, 1894, and 1901.

1883.—Notable decreased yields in New York, the South Atlantic States, Ohio Valley, Lake region, Minnesota, and Iowa.

1886.—Severe drought in Kansas, Nebraska, the Dakotas, Iowa, Minnesota, and western Wisconsin.

1890.—Decreased yields in Ohio and Indiana, Iowa, Nebraska, Kansas, Kentucky, Tennessee, Alabama, Arkansas, and Texas, due to a drought of unusual severity in the great corn States; other less notable reductions in yield in other States.

1893.—Decreased yields noted particularly in Rhode Island, New Jersey, Pennsylvania, South Carolina, Ohio, Indiana, Michigan, Kansas, Arkansas, Colorado, and Wyoming. ("The drought of 1894 was the culmination of a period of deficient rainfall and high temperature that began during the early summer of 1893."—A. J. Henry.)

1902.—During June corn suffered from drought in the central and west Gulf States. (Early corn was injured by frost in the Ohio Valley and Lake region, and late corn was seriously damaged by heavy frosts over the northern portion of the corn belt, more especially to the westward of the Mississippi River.)

1903.—Drought prevailed in the northern portion of the Middle Atlantic and the New England States from May 15 to about the middle of June.

CROP PRODUCTION ALONE NOT A MEASURE OF THE CONDITION OF AGRICULTURE.

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The question as to whether crop production per acre is increasing or decreasing is of so general a nature as to have little direct relation to the condition or needs of the agriculture of the country as a whole. A large number of factors will always be found working toward increased production, and a large number toward diminished production. In one region the balance will swing one way; in another region the other way. The general average for the whole country is merely an arithmetical mean and becomes of interest only when a detailed analysis of the facts reveals some general efficient cause for the observed advance or decline.

Agriculture in this country is now passing through a period of rapid changes. In many ways its condition may be compared with that of electrical engineering a quarter of a century ago, when discoveries succeeded each other so rapidly that expensive machinery and equipment were often relegated to the junk heap before the varnish had been dimmed.

The constantly extending applications of science to agriculture are working revolutions in farm practices; great changes are taking place in the crops grown, the methods of culture, and in the handling and disposal of the crop itself. These applications of science to farming, which have assumed importance only during the last twenty-five years, make for increased production and for increased certainty of production.

The demonstration that the leguminous crops enrich the soil in which they grow with nitrogen abstracted from the inexhaustible atmospheric supply has, at a single stroke, solved the problem of a cheap and convenient supply of the most important and most expensive element of plant food and the very one whose exhaustion was greatly feared by leading men of science scarcely a decade ago. The proper utilization of leguminous plants in crop rotations becomes, in the light of this discovery, of absolutely fundamental importance in agriculture. Already production has been greatly increased in many sections of this country through the skillful use of alfalfa, clover, vetches, cowpeas, and others of the beneficent crops of the pulse family.

At the same time, thanks largely to the researches of the investigators connected with state experiment stations, much has been taught the farmer as to the needs of various crops and soils in other elements of plant food besides nitrogen. At the same time the state fertilizer controls have rendered fraud and excessive charges almost impossible. No one familiar with American agriculture, especially in the Eastern States, can deny that vastly increased production has resulted from this work of the state experiment stations in preventing fraud in the sale of artificial fertilizers and in showing how fertilizers can be used to the best advantage.

During the past three decades great progress has been made in recognizing, curing, and preventing plant diseases, the most insidious of the farmer's enemies. Tens of millions are saved annually to the country by the use of up-to-date methods of fighting insect and fungous enemies. In many cases both the pests themselves and the possibility of preventing their injuries were alike unknown two decades ago. Vastly increased production and, what is even more important, increased certainty of production have resulted from this brilliant new arm forged by science for man's protection.

Plant breeding—a branch of applied science having even greater possibilities for aiding the progress of agriculture than plant pathology—is of still more recent birth. General interest in the methods and aims of plant breeding dates back scarcely a decade and, as would be expected, only a tithe of what will be done has as yet been accomplished. Nevertheless, great increases in yield, in uniformity of product, in hardiness, in drought and disease resistance, and in other useful qualities of our principal crop plants have already resulted from the tireless activities of a handful of enthusiastic disciples of the new branch of applied science.

The organized work in the introduction of new and superior varieties of crop plants from all parts of the world is even younger than plant breeding, yet already half a dozen new crops, yielding products whose annual value reaches into tens of millions, testify to the striking utility of this line of work.

The scientific study of the soil and of climatic and cultural needs of the varieties of our principal crop plants has only just begun, but is sure to become of the greatest importance in growing crops with the maximum of efficiency—utilizing plants to the utmost through an intimate knowledge of their strong and weak points—in other words, growing crops by brains. In preventing "booms" that ruin thousands through false ideas as to the needs and limitations of crop plants, great good will be accomplished by life-history investigations. Much progress has been made already in the working out of the merits and demerits of the numerous new varieties of cotton, corn, alfalfa, date palms, and other staple crops that have been placed at the disposal of the experimenter during the past decade through the activities of the plant introducers and plant breeders.

As plant breeding and plant introduction advance, the need becomes more acute for a critical analysis and study of all varieties of crop plants, with a view to growing them in the localities and in the manner they require to secure the maximum yield. These three new branches of agricultural science—plant breeding, plant introduction, and plant life-history investigations—will, developing hand in hand, revolutionize all branches of crop production and ultimately greatly increase the yield per acre and decrease the risk of failure.

Recent investigations in the methods of picking, packing, and shipping perishable crops, especially fruits and vegetables, have decreased the cost and increased the amount of the net yield per acre of these crops. All branches of agriculture have been stimulated by the great advances in transportation facilities, by the extension of the rural free delivery, the discovery and extension of the telephone, the invention of the milk separator, improved farm machinery, and other mechanical aids for the farmer.

In the light of these numerous applications of science to agriculture, most of them of very recent date and most of them potent for good, it would seem an idle question to ask whether crop production is now increasing or diminishing.

As a matter of fact, however, there is a reverse side to the picture, and many powerful factors are at work tending to lessen production.

First of all, there has been a slow but general decline in the fertility of farm lands since the forests were cleared and the prairies broken. Wasteful methods of husbandry have contributed and erosion has been insidiously at work until in some regions the decline in productiveness has become alarming.

This decline of fertility in the older parts of the country has been both emphasized and aggravated by the bringing into culture, during the last forty years, of enormous areas of exuberantly fertile new lands of the Great Plains, which through improved methods of transportation have been enabled to compete successfully with regions thousands of miles away. This sharp competition of virgin soils in the West has in many cases prevented in the East the profitable use of commercial fertilizer in growing the accustomed staple crops, and has forced a complete change of farm practices, often ending in cultivated fields being turned into permanent pastures or wood lots.

Agricultural labor has become poorer, scarcer, and much dearer during the last few decades. The immigration, largely of the country peasantry of northern and western Europe, formerly so abundant as to furnish a steady supply of the best kind of farm labor, has in recent years almost ceased, and the hordes of immigrants now flocking to our shores from eastern and southern Europe are largely from the cities and even when they are peasants are so unfamiliar with our methods of agriculture as to be of little worth as farm hands. As a matter of fact, few seek employment in the country when they reach the New World.

The growth of the great industrial centers has also acted to draw laborers from the country to the mines and mills where wages were higher and where the eight-hour day is possible, the latter something almost impossible for the farmer to grant. There can be no doubt that the increasing scarcity of good farm labor has in many regions led to a considerable decline in production.

The present industrial tendency to form gigantic trusts that control the marketing of commodities, with little regard for supply and demand, has been brought sharply home to the farmer by the success of the beef trust in stifling competition and manipulating the transportation and sale of live stock to its own advantage. Improved methods of farm practice tend to turn as many crops as possible into the more easily transportable form of cattle, hogs, sheep, and other live stock, and the success of the beef trust in controlling prices to the disadvantage of the farmer has greatly impeded the spread of better methods of farming and in many cases led to a direct decline of production.

Finally the most important cause of decline in production and decay in the intellectual tone of many of the older farming communities is the draining off of almost all the brighter minds to the large cities. The wide ramifications of the modern railway, telegraph, express, and other large business enterprises, have enabled them to take on as apprentice the bright country boy at the small station and gradually promote him as he develops, each step away from the country and toward the great city.

Even the state agricultural colleges and universities of some of the great agricultural States have acted practically as great employment agencies run at state expense to get farmers' boys and girls paying positions off the farm.

The bright country boy, tired of the endless chores of the farm, finds that he can be educated to be an electrical engineer, a civil engineer, a printer, an architect, a machine-shop foreman, or in any one of a dozen other professions that appeal to his youthful mind because of the attractiveness and stimulating character of the work and because of the relatively high salaries paid to the best young men shortly after graduating.

The farmer's son is too young (in some institutions he must choose his future career when he is only 15 years old) and too inexperienced to see the drawbacks in such careers—that he usually is a hired man all his life; that his children grow up in the big cities and almost never equal their parents in energy or initiative; that his own health declines, and that cares multiply faster than his salary increases. All this is wrong. Positions in the technical world should be filled largely from the city population that can not under any ordinary circumstances become farmers.

A fair proportion of the brightest minds should be induced to remain on the farm, and to do this every effort should be made to make farm life attractive to the bright boys and girls. It is a great mistake to imagine that mere technical discussion on methods of farm practice, with which the farmer's boy is often more familiar than his instructor, or purely mercenary motives, can hold the boy on the farm. He knows, even if his salaried instructor does not, that the intelligent boy with little or no capital can make much more off the farm than on it—at first.

The remedy lies rather in the study of science, whose recent brilliant applications to agriculture tend to interest the talented youth not only in the direct improvement in crop production, but also in science itself, which he finds to be a fascinating and stimulating mental discipline, at the same time work and recreation, a noble study much broader and much more satisfying than any of the practical applications that may be made to the industries, important and interesting as they are.

Farm life, with its multitudinous contacts with nature, with its intimate relations to the biological and physical sciences, is really the ideal place for the scientific investigator. Already the tendency is being manifested in plant breeding to decentralize and to put on the farm the breeding up of races of the crop plants under the particular environmental surroundings they must endure when grown on a commercial scale. Commercial success has already been attained by plant breeding on the farm. The intellectual interest aroused by the breeding of a new flower, a new berry, or a new and superior strain of corn far exceeds in importance the not inconsiderable money value of such new creations.

Other lines of research can, with great advantage, be moved out to the farm, where research is conducted under the most favorable conditions by persons themselves vitally interested in the problems and thoroughly familiar with the local conditions. In large institutions it is necessary to turn over more and more of the actual work of investigation to assistants, often poorly fitted and but superficially interested in the problem.

Farm research, however, is not merely a remote end devoutly to be hoped for; it exists now, and it is to further it and to work further decentralization of research that private, state, and national effort should be directed. It is true that only a few men are able to undertake the more difficult lines of scientific research, but it is just these few who, living on the farm, will be the leaders of their communities in the improvement of agriculture and the helpers of their neighbors in minor but still vitally important lines of experimentation. It is always the gifted few who are able to look beyond the immediately pressing problems of the day and plan for the future.

To drain the country of its brightest minds in the future as completely as has been done during the past few decades is to invite the complete intellectual decline of the farming class, the entry of rich landowners, and the creation of a servile tenantry, possibly with a resultant increased production per acre, but at what a cost!

To increase the attractiveness of farm life and to add intellectual interest to rural occupations, to encourage with every means at the disposal of the Government the country boy who honestly tries to seek for truth, with the end in view of retaining a fair proportion of the brightest minds on the farm, should be given immediate attention before it is too late. A free, active, and intelligent country population is the backbone of any country, and no increase in wealth, no triumphs in the industries, can permanently offset the loss of the nation's greatest asset.

THE AGRICULTURAL RESOURCES OF THE EASTERN UNITED STATES; THEIR DEVELOPMENT AND CONSERVATION.

By E. C. Chilcott,
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Within the last few years the idea that the agricultural resources of the United States are being rapidly depleted, and that crop production per acre is rapidly falling off, seems to have met with quite general acceptance. I do not believe that this idea is in accord with either the official statistics furnished by this department and the various state organizations dealing with the subject or with the observations of those who have given the subject the most careful consideration. It is not difficult, however, to see how such an impression might be made upon the mind of the superficial observer, or one who was interested mainly in studying the subject from the viewpoint of the great transportation companies. It is undoubtedly true that there are many farms located in nearly, if not quite, every county of the United States where the production of some one crop has materially decreased within the last decade. It is also probably true that there are many farms where not only one crop, but all of the crops produced have decreased both in aggregate quantity per farm and in yield per acre. But, on the other hand, there is an equal or greater number of farms where an increase both in aggregate production and in yield per acre has been experienced. So that, on the whole, when the entire country is taken into consideration, both the yield per acre and the gross amount produced have been on the increase, not only for the last decade but for the last quarter of a century. It would be manifestly impossible, in an article of this length, to point out the many combinations of causes that have led to the increase or decrease of crops upon farms, either considered individually or grouped by counties or States. I think, however, that a consideration of a few concrete examples that have come under my observation may help to throw light upon the problem.

AGRICULTURAL CONDITIONS IN WESTERN NEW YORK.

Upon paying a visit to a locality in western New York with which I had formerly been very familiar, after an absence of twenty-three years I noted many facts which I believe have a very direct bearing upon the subject under discussion. Among these are the following: I found that many of what had formerly been the richest and most productive farms located within a radius of 12 miles of the city of Buffalo had very materially decreased in agricultural production, although their value, due to their proximity to the city, had considerably increased. An inquiry into the reason for these conditions revealed the fact that in nearly every instance the cause of the decreased production was not due to a decrease in the fertility or productive capacity of the farm, but was on account of the difficulty in obtaining efficient farm laborers at a reasonable price. The cause of this scarcity of farm laborers was generally attributed to the fact that the immense growth of manufactures in the city of Buffalo had served to attract the laborers who were formerly engaged upon farms. These manufacturers paid higher wages than the farmers were able to pay, but, on the other hand, the opportunities for morally and physically healthful surroundings are very much better upon the farm than in those parts of the city occupied by the laborers in the factories. This consideration seems to be generally overlooked by the laboring classes. They consider only the difference in cash wages without any regard to the relative amount of comfort and the welfare of their families in country and in city. I believe that right here is an opportunity for a campaign of education and enlightenment. If the laboring classes in the congested manufacturing centers could be shown the desirability of establishing homes where they could rear and educate their families in a morally and physically healthy environment, where they could have a small piece of land upon which to raise a very considerable portion of the food required by the family, without any expense whatever except the labor of those members of the family not actively engaged as wage-earners, it would seem that there could be found many men, now engaged as laborers in factories, but who had formerly had sufficient experience to enable them to perform the ordinary work on a farm in a satisfactory manner, who would gladly exchange the somewhat higher wages obtainable in the city for the advantages offered by the country.

Another important factor which always has operated and which always will operate to deplete the ranks of farm laborers is the fact that the more progressive among them are constantly becoming themselves landowners. The cheap lands of the West have proved very attractive to this class, and as the western lands have increased in value these people have turned their attention more and more to the relatively cheap but poorer lands of the Eastern States. This movement, of course, should be encouraged rather than discouraged, as many of the very best farmers in this country originally belonged to this class. In fact it may be said that the agricultural development of the Central and Western States is due very largely to men who had formerly been employed as farm laborers, and who by frugality and economy had succeeded in saving enough money to enable them to get a start for themselves where cheap land was obtainable.

The explanation of the seemingly anomalous fact that many of the rich farms of western New York have very considerably increased in value and at the same time have decreased in productivity is probably as follows: Many of these farms have been inherited by their present owners and are looked upon not as investments of so much capital but rather as inheritances that should be retained in the family regardless of the fact that they are not yielding a fair interest on the investment. In other instances, the owners realize that their farms are not profitable investments under existing economic conditions, but they believe that conditions will so change that their farms will eventually prove to be so, and this hope, combined with the sentimental reasons already mentioned, serve to discourage any general tendency to sell this class of farm property. A sufficient amount of real estate transfers is being made in the vicinity of these farms to establish and maintain a market price for land, but in almost every instance the purchasers are either men of wealth from the city, who buy the farms for country homes or as a fad where they may spend the money which they make in other lines of business, or foreigners, mainly Germans, who depend largely upon the members of their own families for supplying the necessary labor for conducting the farms. Very few farmers or successful business men would consider this class of farms a profitable investment where all of the labor must be hired.

Where the changes described in the preceding paragraph have been taking place changes of an entirely different nature have occurred within a few miles. Land much inferior in intrinsic agricultural value and a few miles farther from the city has been bought up within the last twenty-five years at a very low figure by thrifty farmers with small cash capital, but with large and industrious families, who, by the application of improved methods of agriculture, have succeeded in bringing what were considered as "worn-out" farms up to a high state of productivity, with a corresponding increase in the market value of the land. The extension of good roads, built by the State, has been a factor in this development, but by no means the most important one.

Here we have two movements in opposite directions—rich farms, owned by intelligent, well-to-do American farmers, getting richer, but less productive, but still increasing in market value, due to proximity to the city, sentimental considerations and hopes of improved economic conditions, which will eventually convert them into paying investments, and poor farms becoming rich and productive mainly because they had become so poor, and consequently so low in price, that they were attractive investments for a class of farmers who are in a measure independent of the labor difficulties experienced by their richer neighbors.

Both of these classes have shared in the general increase of knowledge of the underlying scientific principles upon which successful agriculture is based, which knowledge has been brought about largely through the investigations carried on by the United States Department of Agriculture and the various state organizations engaged in the enlightenment of the American farmer.

It is probable, however, that as a broad generalization, the extent to which each class has been able to profit by this knowledge has been in inverse proportion to the amount of knowledge acquired and the intellectual capacity of the farmers. Those families which are but slightly in advance in education and in general intelligence of the peasant classes of the Old World, from which they sprang, can more successfully cope with the sociological and economic conditions with which the American farmers of to-day are confronted than can the more highly educated and intelligent class who have acquired many artificial tastes and refinements which make it very distasteful, if not altogether impossible, for them to conform to the simpler requirements of their poorer neighbors. From these and many other considerations I believe it is safe to assume that the problems most urgently demanding solution by the farmers of western New York are economic rather than agricultural in their nature. What they want to know is how to secure efficient farm laborers to enable them to apply what they already know, or can easily learn, concerning agricultural methods rather than an addition to their fund of agricultural knowledge.

Another serious disadvantage at which the farmers of western New York are placed is that with improved transportation facilities they are coming more and more directly in competition with the West in the staple farm products and with the South in truck crops. They also, in common with the farmers of the entire country, lack organization in the marketing of their crops. Here is another profitable field for the Department of Agriculture. If local shipping associations were organized throughout the entire country on substantially the same basis as the truck growers' associations of Long Island and other truck-growing districts, and these local associations organized into a national association, an immense amount of loss to farmers could be prevented and the consumer would not only be able to procure all kinds of farm and garden produce in much more wholesome and attractive condition, but at less cost than at present. It would take some time, much earnest effort, and the expenditure of considerable amounts of money to effect such a national organization, but it could be accomplished, and when well established it would be not only self-supporting but a source of revenue to the stockholders, and it would be able to so control the production, distribution, and marketing of all kinds of farm produce as to prevent overstocking of markets, loss in transit by reason of products being shipped in bad condition, exorbitant commissions and freight charges, and many other evils which now are a heavy tax upon both producer and consumer.

SOME PHASES OF AGRICULTURAL DEVELOPMENT IN THE MIDDLE WEST.

The last quarter of a century has witnessed the passage from the pioneer stage to a fairly stable agricultural state of an immense strip of fertile country extending from the Canadian boundary on the north to the Gulf of Mexico on the south, and from western Minnesota and Iowa, eastern Kansas, Oklahoma, and central Texas on the east, to western North Dakota, South Dakota, Nebraska, Kansas, and western Texas on the west. During this period some rather curious results have been produced in the way of crop yields, both per acre and per farm. At first it would seem that the opening up of a new country like this would result in constantly increasing yields per acre and per farm of all the staple crops, and that any deviation from this rule would indicate soil depletion. Such, however, is not the case. There are thousands of farms within this area which are not producing as much of any of the staple crops as they have produced at some period since they were first opened up, and yet some of these farms are becoming richer rather than poorer, and very few, if any of them, have suffered soil depletion proportionate to the decreased yields.

Probably a majority of the farmers in this area went in debt, if not for the land itself at least for the buildings and equipment. Every effort was then made to obtain the largest and quickest cash return from the farms in order to pay off this indebtedness as soon as possible. In this effort to get out of debt the farmers spared neither themselves, their families, their laborers, their teams, nor their farms. Everything, from the vital energy of the farmer and his family to the fertility of the farm, was converted into dollars to pay off the indebtedness, or to purchase more land, build more and better buildings, or to buy more or better stock. This stage of development usually marked the maximum production of the more bulky and quickly salable products of the farms, but in comparatively few instances was this maximum production maintained for a long term of years. Sooner or later some combination of circumstances would occur to bring about a reaction. This reaction took many different forms, each individual case being controlled by a somewhat different combination of factors, not the least important of which was the personal equation of the farmer and his family; but whatever form it took, in a large majority of cases it resulted in a decreased output of some one or more of the staple farm products. Sometimes the controlling factor was the depletion of the vital energy of the farmer or his wife; sometimes it was the fact that the goal which the farmer had set out to reach was attained, the farm was paid for, the new house or barn was built and paid for, the additional piece of land had been secured, or some other task which had been undertaken was finally finished; sometimes the need of educational and social advantages for the family caused the farmer to move to town, and to let his farm to a tenant who would not maintain the yields at the standard set by the owner; sometimes, and far too often, the pathetic example presents itself of the farmer and his wife who have worked and struggled and suffered privations and worn themselves out in order to provide a farm home where the family could all be together and the children a comfort and support to their declining years, only to find, when all these sacrifies had been made, that the children would abandon them and leave them with a farm on their hands that they were no longer able to manage without help.

In a good many instances farmers have come to the conclusion that the transportation, grain commission, and packing companies have secured such control of the market prices of all farm products that the margin of profit left for the farmer is so small that it does not pay him to work either himself or his farm to full capacity; so he has adopted the plan of reducing his expenses both of cash and vital energy as low as consistent with a fairly good living for his family, and is simply conserving the resources of himself and his farm until such time as he hopes may come when the farmer will be able to secure a fair share of the profits of his labor.

It would not be a difficult matter to extend the enumeration of the causes which have resulted in decreased farm yields in the Middle West during the last twenty-five years. If, however, I have not already shown that there are many causes other than soil depletion, any further extension of the list would also be equally ineffective. It is not claimed that any or all of the causes are sufficiently general to have actually reduced aggregate crop yields for entire counties or States, but that they are of sufficient frequency to account for the somewhat generally accepted theory that the agricultural resources of this country are becoming rapidly depleted, and they have undoubtedly seriously affected the statistics on the subject.

Another factor that has undoubtedly tended to decrease the average yields, as shown by the statistics of the Middle West, is the fact that much experimenting is being done in attempting to establish agriculture in the semiarid regions where methods have not yet become fully adjusted to climatic conditions, with the result that many very low yields, if not complete failures, are met with.

AGRICULTURAL CONDITIONS IN NORTHERN VIRGINIA.

The agricultural conditions in northern Virginia have not yet recovered from the effects of the civil war, although nearly a half century has elapsed. The former slaves have died or become incapacitated by age, and the younger generation of negroes are very inefficient and unsatisfactory as farm laborers, and their presence tends to discourage the introduction of white laborers on the farms; the result being that labor conditions are even worse here than in the North and Northwest. This portion of the State is producing but a small fraction of what it should. There seems to be an impression that because a large portion of the land is lying idle and yielding no agricultural returns whatever, but is being allowed to grow up to scrub pine and worthless shrubs and weeds, and that because much that is being farmed produces but indifferent crops, that the land is worn out. That such is not the case is, in my judgment, proved by the fact that scattered all over northern Virginia are to be found farms, formerly considered worn out but which have been brought up to a high state of cultivation and are now yielding good returns. The number of these farms is constantly on the increase, and if some solution could be found for the labor problem, it would be quite reasonable to predict that the agricultural production of northern Virginia could be quadrupled within four or five years. It is believed that much the same conditions prevail over a large portion of the entire South.

That the crop yields of all staple products throughout the South are on the increase can not, I think, be questioned, as all available evidence points in that direction. An interesting and significant bit of evidence on this point was secured from an attorney for one of the important southern railroads. I asked his opinion concerning the increase or decrease in crop yields throughout that portion of the South tributary to his road, and he answered immediately and emphatically that there was a marked increase in the yield of all staple farm products, and he went on to state that he had just returned from a meeting of railroad managers where this very point was under discussion, and that after careful consideration of the reports of those who had charge of this question they had come to the conclusion that the yields of all staple crops along the lines of their several roads had been sufficient to warrant them in advancing the freight rates. This was a strong and somewhat unexpected corroboration of the conclusions at which I had already arrived. First, that crop yields are on the increase; and, second, that the transportation companies have better facilities than anyone else for obtaining information concerning any such increase and that as soon as they learn of it they immediately adopt measures to secure to themselves rather than to the farmers any benefits that may come from such increased yields.

UNDEVELOPED RESOURCES, EAST, WEST, AND SOUTH.

Ever since the beginning of American agriculture it has been the custom to refer to "the vast undeveloped agricultural resources of the boundless West." There are still vast undeveloped agricultural resources in the West, but they can no longer be considered "boundless." On the other hand, thousands of eager land seekers and home builders are diligently seeking out every nook and corner of the West that is suited to agriculture, and it is probable that in their eagerness to secure cheap land some of them are attempting to establish homes and farms beyond the bounds of what may safely be considered the agricultural areas.

This tide of pioneers and home builders has been moving steadily westward from the very beginning of American history, and the West has heretofore welcomed them and afforded them with a bountiful hand the opportunities they were seeking. The West will always welcome brain and brawn from the East, and there will always be opportunities there for the right kind of energetic young men and women; but the opportunities to secure cheap land are rapidly decreasing and will at no distant date be little, if any, better than in the East and South. When that time arrives, what is to become of the constantly increasing agricultural population? I predict that it will take the form of a return wave which will bring back to the East and South some of the most energetic and progressive young farmers of the West, who, untrammeled by eastern and southern traditions and customs, will quickly recognize and take advantage of the vast undeveloped agricultural resources of these sections. When that time arrives it will be possible to increase the agricultural production of the country to meet any demands that are likely to be made upon it for many generations to come.

I would therefore sum up my impressions concerning the agricultural resources of the eastern United States, their development and conservation, as follows:

SUMMARY.

1. Crop production per acre is not falling off, but is increasing.

2. The seeming decrease in crop production is generally due to one or the other, or both, of the following causes: (*a*) Changed economic or sociological conditions which have tended to reduce or remove the incentive to maximum production; or (*b*) farmers adopting a more conservative system of farm management which will provide them and their families with a comfortable living with a minimum expenditure of labor—a conservation rather than a dissipation of the potential resources of their farms, with frequently a very marked decrease in the amount of produce sold from the farms, particularly of the more bulky products, such as wheat and corn, which pay a relatively high freight rate in proportion to their value.

3. Agricultural production can best be increased by adopting vigorous measures to remedy faulty economic conditions, and these measures should be directed along the lines of insuring to the farmer a fair share of the price paid by the consumer. This can be accomplished by developing methods of delivering agricultural products as directly as possible from the farm to the consumer in wholesome

and attractive condition, without unnecessary loss or expense in transit and without exorbitant profits to transportation companies and middlemen; and by providing competent and efficient farm laborers at a reasonable wage, including comfortable and attractive country homes.

4. Improved methods of agriculture involve the use of much additional machinery. The manufacture of this machinery is now largely under the control of trusts or combinations which destroy or at least restrict competition and increase the cost to the farmers. Measures should be adopted to prevent such combinations and to insure to farmers an opportunity to purchase all kinds of agricultural implements and machinery at a fair price above the actual cost of manufacture.

5. Liberal appropriations should be provided by Congress and by the several state legislatures for the development of the agricultural investigations now so well under way by the United States Department of Agriculture and by the various state agricultural colleges and experiment stations.

6. No undue effort should be made to stimulate agricultural production until the present faulty economic conditions are corrected, but the campaign for the education of the farmer should be vigorously prosecuted, in order that he may be prepared to meet the demands for increased production when economic conditions have been so corrected that it will be profitable for him to do so.

7. Under proper economic conditions, and with the assistance which will be given him by the United States Department of Agriculture and the state agricultural colleges and experiment stations, if properly supported by liberal appropriations, the farmer will be able to meet any and all demands that are likely to be made upon him for increased agricultural production for many generations to come.

AGRICULTURAL PRODUCTION AS A NATURAL ASSET.

By C. S. Scofield,
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With comparatively little exception American agriculture is in a condition of transition; that is to say, there are few regions of any considerable extent where any particular kind of agricultural production has been long enough continued to be considered as really permanent. A variety of causes has contributed to maintain this condition, some temporary and others permanent, some economic and some natural, or more truly agricultural. In fact, it would seem that as in the case of our field crops, where a change in the sequence of crops on the same soil has a beneficial effect, so, too, in the type of production for whole regions, a periodic change of some sort has taken place.

As a nation, we have passed through the period when the agricultural production of each region was made as diverse as knowledge and environment would permit, in order to supply local needs, since the transportation of staple products was necessarily expensive. Following there came a rapid extension of agricultural settlement, together with an equally rapid development of means of overland transportation, and this has resulted in a relatively high specialization in crop production, or a localization of crop production to those sections best adapted to the various crops. This tendency toward specialization is now going on at a rapid rate, promoted alike by those agencies which are introducing new crops, and by the zeal of many of our people in seeking crops that will give the quickest and largest returns.

Reactions away from this high degree of specialization are naturally induced by competition in production, by the relatively high cost of transportation, and by the reduced yields which naturally follow the lack of a proper rotation of crops. In looking over any particular section of our agricultural region it becomes apparent that, as regards the kinds of crops and methods of farming, the present condition is essentially temporary. The crops and methods are either newly in vogue or so distinctly unsatisfactory that some change is obviously imperative. Thus the history of our older agricultural sections is a history of the rise and decline of agricultural industries. It is important to keep these facts in mind in making any prognosis of the future of our agricultural productions. As an agricultural people we have not yet "found ourselves."

This being the case, we have as yet no adequate measure for estimating with any degree of accuracy our potential agricultural resources. We hear much of the high productive capacity of the virgin soils of our new regions as compared with that of the worn-out soils of the older regions, but the so-called "exhaustion" of the soils that have been under the plow for one hundred or two hundred years is more apparent than real. It would be difficult, if not impossible, to find any instance of the complete exhaustion of the producing capacity of the soil. It is true that bad methods of farming may render a soil temporarily unfit for profitable production, through the depletion of the supply of organic matter, through ravages of some weed or insect pest, or the ascendency of some plant disease. Any of these difficulties are essentially temporary in character and may be overcome by proper methods of farming.

While it may be true that in time a soil may become unfit for the profitable production of some one crop or group of crops, there is no evidence that any of our once productive soils have as yet become wholly and irredeemably unfit for some kind of profitable agriculture, nor is there any satisfactory evidence of a real irretrievable decline in the productive capacity of any of our truly agricultural regions. Until we have some definite evidence of such a real decline in producing capacity, it will be necessary to accept the conclusion that the productivity of our soils would be maintained indefinitely if a proper sequence of crops and agricultural industries were used.

The relation between the sequence of crops grown on the land and the change in the predominance of industries in a region is necessarily close. Where the sequence of crops is improper, as in the case of the long-continued production of a single crop, or the use in rotation of crops that rapidly reduce the supply of organic matter, the change from one industry to another must come at frequent intervals. If, however, a less destructive system of rotation is followed, so that the producing capacity of the soil for that series of crops is longer maintained, the change from one industry or set of industries to another may be much longer postponed. These facts have been appreciated, more or less unconsciously, by the great body of our farmers. The wisdom of using a rotation of crops and of maintaining the supply of organic matter in the soil is almost universally realized, though, unfortunately, not universally acted upon. When, for one reason or another, one crop or group of crops can no longer be profitably produced in a region, other crops come into use and new industries are established. Owing to this important fact the future outlook is encouraging.

Our greatest national agricultural asset is the character and intelligence of our farmers. If the present high standard of character and intelligence is maintained or improved, the nation need have little fear for the future of its agricultural production. At the present time the mean of our agricultural production is far below the possible maximum, both in gross amount and in yield per area in crop. The present low mean is largely the result of economic conditions. Any material readjustment of these conditions that would require or reward an increase, either in the gross amount of production or in the yield per area, would find an immediate and adequate response. Though the farmers have already done much in using crop rotation, in improving their methods of farming, and in accepting new crops and starting new industries, the end along these lines is not in sight; indeed, only a beginning has been made.

Better rotations are constantly coming into use, better methods of farming are being followed, new and improved crops are constantly finding their places.

The readjustments that take place in our economic conditions must be accompanied by many readjustments in our agricultural production. A higher degree of specialization in crops and methods must be expected in some regions, together with more diversification in others. The facility with which our farmers respond to these economic readjustments, and with which they continue to accept improved methods and more valuable crops, will very largely determine, not only their individual success, but their value to the nation. It becomes, then, a matter of the first importance to insure the maintenance of a high degree of character and intelligence in our farmers. If the future of our agricultural production is threatened, it is through the lowering of the grade of our farmers rather than through the exhaustion of our soil fertility that it is more likely to come.

AGRICULTURAL PRODUCTION.

By W. J. Spillman,
Bureau of Plant Industry, United States Department of Agriculture.

Is crop production per acre falling off? This question must be answered both yes and no. Our study of individual farms leads us to believe that on about 50 per cent of the farms of the country crop production is falling off. The other 50 per cent is about holding its own or increasing slightly. Exceptionally there is a farm on which yield per acre is enormously greater than it was a few years ago. Statistics which have hitherto been gathered on this subject do not reveal the actual status of affairs. These give average yields by States or by counties. They take no account of lands abandoned or put into cultivation, an important factor in many sections. The abandonment of worn-out land and the putting of new land into cultivation may keep up average yields. Nor do statistics reveal the fact that increase in average yields for a given territory is largely due to enormous increases on comparatively few farms, a fact that our investigations reveal to be true. On the whole, the yield per acre of our principal crops has increased slightly for the past two decades, as shown by the following figures:

Average yield per acre for five-year periods.

	Wheat.	Corn.	Oats.	Cotton.
	Bushels.	*Bushels.*	*Bushels.*	*Pounds.*
1891 to 1895	13.4	23.6	29.0	172.3
1896 to 1900	13.2	25.5	23.2	192.4
1901 to 1905	13.9	[a]27.6	33.0	184.6

[a] Owing to the low yield in 1901, on account of the severe drought, this average is made up for the period from 1902 to 1906.

There is no question that on something like half of the farms of this country the yield is less than when the soil was new. The underlying causes for the condition now existing with reference to crop production are easily apparent to the student of agricultural history and methods.

EXPLOITIVE FARMING.

In a state of nature, soils which are well adapted to the growth of vegetation are maintained in a high condition of fertility. Plant roots thread the soil to great depth. When they decay they not only furnish plant food for succeeding generations of plants, but provide humus, which aids in storing moisture and, perhaps, in removing from the soil deleterious substances thrown off by plant roots. In addition, the continual decay of plant roots leaves channels in the soil which open it so as to permit a free circulation of air and moisture. Animal life in the soil adds to its permeability by making burrows. In some sections of country the common fish worm penetrates soils to great depths, making channels which carry down rain water and thus prevent it from flowing off the surface. For these reasons all soils when first put into cultivation, which are well adapted to the production of plants, are highly fertile. Experience in many States has shown that good virgin soils for approximately half a century after they are put into cultivation will produce good crops with practically no attention to renewing their fertility. Under such conditions the farmer, who naturally follows the line of least resistance, will exploit his soil. He adopts types of farming akin to mining, and continues to draw on the resources of the soil's fertility until it is exhausted, before lessening yields compel him to adopt more expensive methods of farming required for maintaining or building up the soil fertility.

On a new and rich soil very little knowledge is required for the production of profitable crops. All that is necessary is to plow, harrow, plant, till, and harvest, which anyone can learn in a short while. Considerable areas of soil are still found in this country from which the fertility has not been completely mined, so that exploitive farming is still practiced with apparent success in some States. These are the more newly settled regions, the most important of which are the Dakotas, the semiarid plains region, and the upper Columbia Basin of Washington, Oregon, and Idaho. In these the original fertility of the soil still suffices for the production of good crops with the most unscientific methods of farming, though in some of them lessening yields are becoming apparent. In some cases the introduction of weeds which are adapted to growing in grain fields have compelled changes in the system of farming, but the change has in the main been from one exploitive type of farming to another. Very large areas of land in this country have now been farmed about long enough to exhaust their original fertility. This is true of the great body of agricultural lands in the Mississippi Valley extending from the Canadian line to the Gulf, and from the Appalachian Mountains to eastern Kansas and Nebraska. The more progressive farmers in this vast area have adopted systems of farming which tend to build up soil fertility. In some sections the change from exploitive to conservative types has been more or less general, in others it is decidedly sporadic.

There are considerable areas, including the territory east of the Appalachian Mountains and most of the cotton-producing States, in which the land has been farmed much longer than was necessary to exhaust the original fertility. In the northern half of the Atlantic coast region the change from exploitive types of farming has been very general and agriculture is on a fairly sound basis, but in the remainder of this region exploitive farming still remains, and crop yields are much less than they were a generation or two ago. There are several instances of exploitive types of farming that have lingered long beyond their legitimate life. These are found on the average cotton farm of the South, in the tobacco fields of Virginia and Maryland, in the corn and wheat fields of southern Illinois, western Kentucky, and southern Missouri, and in the cornfields of the hill country of the South and of northern Arkansas. The great wheat fields of northern California have just reached the point where waning fertility is evident in the low and generally unprofitable yields. The Willamette Valley of Oregon passed through this stage a dozen years ago, and in that section the change to fruit raising, dairying, and other types of live-stock farming are rapidly bringing the soil back to its original fertility.

COMMERCIAL FERTILIZERS.

The early period of exploitive farming usually gives place to a short period of diversification, during which the more progressive element among the farmers experiments with new types of farming, live stock becoming an important factor. In a short while the best forms of live-stock farming for a given locality are determined and more permanent systems of farming are developed. These maintain or increase the fertility of the soil. But the change from exploitive to conservative types is a difficult one to make. The fact has already been noted that exploitive farming requires only a small degree of intelligence on the part of the farmer. On the other hand, any form of live-stock farming requires more constant attention and a very much greater degree of intelligence. Farmers are prone, therefore, to continue the less strenuous system to which they have been accustomed. In the North, where satisfactory grasses and clovers were early found, and where there are no special difficulties in the way of development of live-stock industries, the adoption of conservative types of farming has progressed in a fairly satisfactory way. In the South, on the contrary, several difficulties have been met with, and the development of conservative types has been greatly retarded.

The difficulty of introducing live-stock farming, especially in the South, and to some extent in other sections, has led to a very general reliance on commercial fertilizers. Twenty years ago the use of these artificial manures was practically confined to the Atlantic seaboard. In the northern part of this section it was confined to the more intensive types of farming, like fruit raising and truck growing, in which the maintenance of soil fertility by feeding stock was out of the question. Farther south fertilizers were very early used in the production of ordinary field crops. The use of commercial fertilizers has extended westward during the past two decades in a remarkable manner. They are now used from the Atlantic coast to eastern Kansas, from the Gulf of Mexico to the Ohio River, and to a considerable extent northward as far as Michigan. According to the census of 1900, the value of commercial fertilizers used in the United States was about $50,000,000. At the present time it is estimated that twice this amount is used. So great has become the dependence on chemicals that in some States fully 10 per cent of the value of the crops is expended in purchasing fertilizers. This is a heavy tax on agriculture, and, while it has served temporarily to maintain yields in most cases, it has greatly decreased the profit from farming. In some sections the continued excessive use of fertilizers has led to injury of the soil from the accumulation of the residue left by the chemicals. Some of the truck soils of the Atlantic coast, on which enormous quantities of fertilizers have been used for many years, have become so charged with these residues that they have been abandoned, and large areas of cotton lands are beginning to show injury from the same cause.

SOIL EROSION.

The northern half of the country has always been more or less covered with various grasses. These have prevented soil erosion except in small isolated areas; but in the South, where a single-crop system with clean culture has been the rule, and where, in consequence, the soils have been left bare during the winter, soil erosion has been an important factor, especially where the land is more or less rolling or hilly. In some sections erosion has proceeded to such an extent that considerable areas have been abandoned.

ECONOMIC CAUSES.

Exploitive types of farming, as already stated, require less knowledge than the more complex types which provide for maintaining soil fertility. Not only that, but they require much less capital. The equipment of an ordinary cotton farm in the South, including buildings, live stock, and implements, does not exceed $10 per acre. On an ordinary grain farm in the West the corresponding equipment amounts to approximately $20 per acre. On a well-equipped hay farm, $40. On the other hand, a properly equipped hog farm must have about $70 per acre expended in buildings, fences, live stock, and machinery in order to put it in condition to return a maximum income. A good dairy farm requires $100 an acre for equipment, and the highest class dairy farms in this country have had $300 per acre thus expended. It is natural, therefore, when we remember that a large part of the West has been settled by pioneers without capital other than their energy and intelligence, that these cheaper types of farming should develop. It is also characteristic for men to live up to their income, hence it is that a change to higher types of agriculture has been retarded by the difficulty of securing sufficient capital. The development of agriculture has, therefore, been retarded both by lack of capital and by the fact that the change from exploitive to conservative types of farming requires knowledge which the average farmer does not possess. In the South special difficulties have existed. In the first place, the prevalence of the cattle tick has made beef production and dairying very precarious. The warm climate has also added greatly to the expense in the handling of milk. Not only that, but the available labor of the South has not been of a type that could easily be taught the management of stock, nor could it be relied on to give that constant attention necessary to success with any class of farm animals. As a result exploitive types of farming have continued in this section long beyond the time when they yield a fair return to labor. This is one reason why the use of commercial fertilizers has extended so much more rapidly in the South than it has in the North.

SHALLOW PLOWING.

In all sections of the country where farming has continued so long that exploitive types of farming are no longer profitable, the decreasing fertility of the soil and the consequent impoverishment of the farmer has led to the use of inferior draft animals, with resulting shallow plowing, so that in many sections only 3 or 4 inches of the top soil is now utilized.

NEED OF INCREASED CROP PRODUCTION.

During the past century the increase in the area of cultivated land in this country has, in general, kept pace with increased demands for farm products, and in some instances has even exceeded these demands. In the case of the wheat crop this is still true. In recent years the lands which have been brought into cultivation have been mainly wheat lands. The average crop of wheat produced during the five-year period from 1895 to 1900 was 540,000,000 bushels. During the next five-year period the average was 660,000,000 bushels, an increase of 22.2 per cent. During the same period the population increased only 9.2 per cent, but during this same period wheat exports decreased over 23 per cent. The increase in the production of corn was slightly less than the corresponding increase in the population. Not only has there been a large increase in area of wheat land in this country in recent years, but there has been a similar increase in other countries, especially in Canada and in Argentina. It is probable that the increase in area of available wheat land will continue for some years to meet increased demands for this cereal, but in the case of corn, the most important crop in this country, conditions are different. For the past few years the increase in the area of corn has not kept pace with the increased demands for this cereal. As a result the price of corn has been higher during the past five years than during any similar period in the history of this country, even with the record-breaking crop of 1906. With the exception of the wheat crop, there is no question that future increases in demand must be met largely by increased yields per acre, and ultimately the same will be true even of wheat. The supply of easily available farm land in this country is well-nigh exhausted. Irrigation projects in the West may add a few million acres and drainage of swamp lands will ultimately add several million acres, but these additions will hardly meet the increased demands for the present and not at all those of the future.

It is fair to assume that the demand for farm products will continue to increase approximately at the present ratio for the immediate future, at least until population begins to press upon the food supply. With practically all of the easily available farm land already in private hands, it is evident that future needs must be met by increased yields per acre. Can this be done? That we shall ultimately reach a condition under which the power of the soil to produce crops can not be made to meet all demands on it seems reasonably certain, but not imminent. When we remember that the average yield of corn in this country is less than 30 bushels per acre, while on the best farms it is more than 100 bushels; that the average yield of wheat is only about 15 bushels, while on many farms it is more than 30 bushels; that the average yield of cotton is two-fifths of a bale, while on many farms it is 1½ or 2 bales, it would appear that with our present area of land it would be possible, by the most approved systems of farming, to feed and clothe twice our present population without requiring too much of the farm. It would probably be possible by united and intelligent effort to double the yield of every important crop in this country. This has been done in the older countries of Europe. In fact Germany, France, and England to-day, on lands farmed many centuries, produce yields practically double those in this country. For instance, the average yield of wheat in bushels per acre in these countries for the period of 1897 to 1906 is as follows: Germany, 28; France, 19.8; and England, 32.2; while the yield for the United States is only 13.8. But to bring about these increased yields exploitive types of farming must be utterly abandoned and in their place types must be developed that provide for maintaining and building up the fertility of the soil. It is no small task to bring about such a revolution in methods of farming.

The point has already been made that conservative farming requires more capital, more expense in operation, and a higher degree of intelligence on the part of the farmer. It also requires better systems of management. How then shall we bring about these better systems of farming which, in the near future, will be necessary to meet the demand for farm produce in this country?

BETTER TYPES OF FARMING.

In the first place, types of farming that maintain or increase soil fertility must be more generally adopted. This means the extension of the various types of live-stock farming and a decrease in the area devoted to crops for sale. It is evident, therefore, that the extension of live-stock farming alone will not meet the conditions. We must, therefore, depend more and more largely upon other means of building up soil fertility. Experience has shown that dependence can not be placed on commercial fertilizers alone. Their indiscriminate use, without attention to the humus content of the soil, has not proved to be satisfactory. Not only that, but the supply of some of the chemicals which have been relied upon in the past to maintain crop yields is not inexhaustible. Practically our whole supply of potash is obtained from a single locality in Germany. The mines which supply this material will undoubtedly be exhausted in the not distant future. The major part of our supply of phosphorus comes from material mined along our South Atlantic coast. As time goes on the supply of phosphorus decreases, and undoubtedly we shall soon reach a period when increased demand and decreased supply will result in a rise in price that will render the use of phosphates less profitable than at the present time. The problem, therefore, is an exceedingly complicated one; even when we exhaust our knowledge of the possibilities in the matter of increasing soil fertility we have not fully met the conditions. This means that scientific investigation on behalf of the farmer, especially as relates to the maintenance of soil fertility, is not yet finished. It is highly important that these investigations should be extended and that encouragement should be given to those who are trying to solve the problems of soil fertility. It is known that much can be accomplished by the growing of cover crops to be turned under for the production of humus. Especially is this true of the legumes, such as cowpeas, soy beans, the vetches, and the clovers. These not only add humus, but because of their power of utilizing atmospheric nitrogen they store in the soil great quantities of nitrogen, the most expensive of all plant foods. The use of such crops, together with a moderate use of commercial fertilizers, greatly enhances the producing power of the soil, and in sections where live-stock farming can not be developed. The farmer must be taught how to use crops of this character. It is seen that the problem is, therefore, largely one of teaching the farmer systems with which he is to a large extent unfamiliar. How shall this be accomplished?

FARM PRACTICE INVESTIGATIONS.

Many of the principles involved in crop production have been worked out through investigations of scientists. On the other hand, practically every intelligent farmer is more or less of an experimenter. There is a vast fund of knowledge in possession of individual farmers of this country, but, generally speaking, the farmer makes no record of his results, and the experience of one farmer is of comparatively little benefit to another. To meet this condition the United States Department of Agriculture has undertaken the investigation of farm practice in all sections of the country. The experience and results of the most successful farmers are collected and correlated, thus adding enormously to our store of knowledge concerning the elements of success in farming. It is fair to assume that half of the growing science of farming, in so far as it has been formulated, is the result of practical experience on the farm; the other half is the result of scientific investigation. While there are many problems yet unsolved, one of the main problems at the present time is how to get knowledge already in our possession into the hands of the farmer. Frequently the problem of the farmer in introducing an important principle into his operations is fully as great as that of the scientist who discovered the principle. There is need, therefore, of a central agency which shall be in intimate touch with the scientist and with those farmers who have worked out important problems, on the one hand, and with the main body of farmers who need information about better systems of farming and better farm methods, on the other. The problem here is that of bringing home to the people the work of the State to aid the farmer. Many agencies are available in this work. The bulletins issued by the States and by the National Department of Agriculture are of much value. The farmers' institutes reach a large number of farmers, and the agricultural press disseminates information; but when all is said and done the fact remains that the average farmer is not in the habit of getting his information from the printed page. He gets it from observation. Not only that, but, as before stated, it is frequently a difficult matter to make use of information, because to do so requires radical changes in the system of farming. An important means, therefore, of getting information into the hands of the average farmer is that of the itinerant teacher. Not only does he become acquainted with the people, thus gaining their confidence, but he learns their problems and he knows the information they need. Direct personal contact is an important factor in influencing the farmer to change his system.

The farmer must be taught how to plan his work with a view to better utilization of farm labor. During the past few years labor has been exceedingly scarce and only those farmers who could give employment the year round have been able to secure sufficient labor to carry on their work properly. Fundamental studies are necessary in order to determine the relation of various types of farming and rotations of crops to the needs of labor at all seasons of the year. These studies are being made by the Office of Farm Management in the Bureau of Plant Industry. The farmer must be taught proper methods of fertilization, improved methods of cultivation; he must be taught the principles of drainage, and in sections where soil erosion is imminent, or is taking place, he must be taught how to prevent it by deep plowing and an abundant supply of humus, and in extreme cases by contour cultivation or by terracing.

IMPROVEMENT OF CROPS.

In addition to better systems of farming and better methods of fertilization, cultivation, etc., much can be done to increase the yield of crops by the introduction of better varieties and by the improvement by breeding and selection of the varieties already at hand. Abundant investigation has shown that an increase of 25 per cent in the yield of our common crops can be produced by the selection of individual plants having high yielding power. There is an especial advantage in this method of increasing crop production in that the use of improved seeds does not require any higher intelligence than the use of ordinary seeds. This is especially true of new varieties of fixed type which are of superior merit, for when the farmer once secures a small amount of the seed of such a crop he obtains a permanent increase in yield, even where his methods are not changed at all.

ACCIDENTAL LOSSES.

The yield of nearly all crops in this country is decreased to a considerable extent by the ravages of insects and by fungous diseases. These are in many cases preventable. The methods required, however, call for considerable intelligence, and constant effort is necessary to get the farmer to use them. It is a legitimate function of the State to teach the farmer the use of remedies for these pests.

It will not suffice to maintain agricultural production merely to teach one generation of farmers how to farm. The personnel of the farming community is continually changing. New men embark in the business and young men grow up to assume the duties of their elders. These new farmers must in the main be taught over again the lesson learned by those who preceded them. The task of teaching the farmer will, therefore, never be finished. It is abundantly demonstrated, however, that when the task is properly done, the soil at present available in this country may feed and clothe a population enormously greater than that which it now does.

INTERPRETATION OF CROP STATISTICS.

By Dr. A. C. True,

Director of Office of Experiment Stations, U. S. Department of Agriculture.

Although the data show an increase in the average yield of different crops for the ten years, 1897–1906, as compared with the average for the forty years, 1867–1906, they do not necessarily indicate an actual increase in the amounts of plant food in the soil, taking the country as a whole, nor do the average low yields for certain periods definitely mean a decrease in the quantity of plant food at those times. It is to be expected, however, that in certain sections this natural resource has diminished through improper management, but the depression is entirely obliterated in the average figures by conditions and circumstances incident to the development of new regions and not infrequently by accidental climatic conditions and other forces.

In the interpretation of the crop statistics for the last four decades a number of factors must be considered. Some of these are general, while others are local and incidental. The influence of our agricultural experiment stations is limited to the twenty years since they became generally established. In most States agricultural colleges have not been well established longer than the experiment stations, while farmers' institutes and other agricultural extension work are of a still more recent date. The agricultural short courses and winter courses, which are now attended by thousands of farmers and farmers' sons, are the development of comparatively recent years. In fact, many of the factors just mentioned can have had an effect on crop production only during the last ten or fifteen years. The principal forces with a bearing on crop yields are the works of the United States Department of Agriculture, agricultural experiment stations, agricultural colleges, farmers' institutes, and state boards of agriculture, the agricultural press, the better adaptation of crops to the conditions of soil and climate by seedsmen and plant breeders, the more liberal and more rational use of fertilizers, better methods of farm management, especially in the diversification and rotation of crops or the introduction and substitution of kinds and varieties of crops in particular sections, the progress in the improvement of agricultural implements, and the increase in the value of the crops and of the land.

All these influences are now widely operative in the United States and undoubtedly are doing much toward the general improvement of our agriculture and the maintenance of soil fertility.

Other factors of wide influence, however, affect the average crop yields of limited periods, and these must be taken into account in the analysis of crop statistics. This is decidedly the case in the periods now under consideration. For example, in considering the average yields for the different decades account must be taken of the fact that during the period of 1897–1906 the number of good crop years was greater than in the preceding decade. Statistics of this department show that from 1887–1896 the average yield of corn was low in 1887, 1890, and 1894; of wheat in 1888, 1890, and 1893; of oats in 1890 and 1893; of barley in 1887 and 1894; of rye in 1887, 1888, 1890, and 1892; of buckwheat in 1887 and 1888; of potatoes in 1887, 1890, 1892, and 1894; and of hay in 1887, 1890, 1891, 1892, 1894, and 1895; while from 1897–1906 they indicate a low average yield of corn only in 1901, of barley in 1900, and of potatoes in 1897 and 1901. This fact contributes as much, if not more than any other, to the reduction of the average yield for the decade of 1887–1896 and the very perceptible increase for the decade 1897–1906. An almost unusual succession of good crop years in the last decade has had its effect in bringing the average for this period above the average for forty years. Undoubtedly some of the larger average yields in the first decade here considered are due to the fertility of new lands, while some of the reduced average yields of later periods may be due to a decline in fertility in some of the older farming regions. The universal custom in new regions has been the continuous taking of crops from the soils without putting anything back in the way of manure, etc.

A strong incentive to farm with greater care and thoroughness is the increase in the value of farm lands and farm products and the consequent increase in land rents. On the one hand, greater returns are required to maintain the rate of income on the present valuation, and, on the other, the enhanced value of the products, together with the rapid decrease of new lands suitable for agriculture, makes it incumbent upon the farmer to use more care and skill in his work.

By considering each crop separately the effect of some of the principal influences tending to raise or to lower the average yield may be brought out more clearly. The increase in the average corn yield per acre in the northeastern part of the country, from Maryland to Maine, has been due, among other things, to the extension of the dairy industry in that section. In dairying, the grain and roughage produced on the farm are fed to the cows and the comparatively large quantities of manure produced are returned to the soil, with the result that the fertility and consequently the average yield is brought up. Furthermore, in the New England States farmers in certain sections are beginning to grow the higher yielding Dent varieties of corn in place of the Flint varieties. Throughout the corn belt seasons have been quite favorable in recent years. The methods of cultivation, largely due to experiment-station work, have been improved, and as a result of station and extension work a much more rational selection of seed corn is practiced. This is noticeably true in Indiana, Illinois, and Iowa, where the average yield has considerably increased during the last decade. The high average yields of earlier periods are probably due largely to the initial fertility of the soil. It is also a fact that as some of the States were settled the best lands were first brought under cultivation, and therefore the average yields are highest in the earliest decade. Kansas and Nebraska and all of the States of the plains were first settled along the river valleys in their eastern parts, where both soil and climatic conditions were most favorable, and for this reason the average yield of crops for this period shows up well, while later on, when settlers worked westward and were obliged to take greater risks, especially with reference to precipitation, the average yields naturally decreased. This condition makes it extremely difficult to definitely interpret crop statistics for the States which were settled during this period. In this case the lower average yields of later decades do not indicate a reduction of fertility. The statistics for corn bring out this fact better than those for wheat, because corn was not so subject to the attacks of the chinch bug in some of the earlier periods.

Wheat production has been very favorably influenced by the introduction of varieties better adapted to certain regions. The durum wheats, introduced by this department since 1900, have proven to be drought and rust resistant, outyielding most spring varieties in dry seasons. About 50,000,000 bushels were grown in 1907, which represents more than one-twelfth of the entire wheat production of the country for that year. In addition the winter wheat area, through the introduction of hardier types, has been extended farther north, this being particularly true in Nebraska, and to a lesser extent in Iowa. In this section winter wheat usually yields better than spring wheat, while the average yield of spring and winter wheat for the whole country shows but little difference. In nearly all those States in which dry farming and irrigation are practiced, the average yield of wheat has gone up, mainly because these methods of farming are becoming better understood, or, in other words, the farmer has become more efficient in the utilization of the plant-food resources present in the soil. In some of the older and principal wheat-producing States where up-to-date methods are in use and where wheat improvement has been carried on by experiment stations and other agencies, the average yield has declined, but this may be taken as showing that on the one hand the soil fertility has gone down, while on the other the opposing factors have not been quite efficient enough to overcome the decline in yield due to this cause.

The same statements in general may be made in regard to oats and barley, and attention may be called to the figures given for Montana, Idaho, Utah, and Washington. These remarkable increases in the average yield do not mean that more available plant food has been added to the soil, but that more finds its way into crops because of improved and more efficient methods. In Wisconsin, Manshury barley, introduced and disseminated by the experiment station, has become the standard barley of the State, and has proved a very practical barley for the Northwest. This is evidently one of the principal factors which has brought up the average yield, almost 4 bushels per acre during the last decade.

The data on potatoes hardly admit of general conclusions. This crop is frequently neglected when other lines of work are more profitable, and especially when the farmer aims to grow enough for his own use only. In some of the Eastern States, for instance, where the dairy industry has recently made such rapid strides, the potato crop, and especially commercial potato growing, has fallen out of favor to some extent and a loss of average yield has been sustained. The high average yield in Maine for 1897–1906 is principally due to the development of the Aroostook County potato-growing region of virgin soil. The Maine Experiment Station has been of very material assistance in bringing into use more rational methods of applying fertilizers and establishing the practice of spraying against potato diseases.

In summarizing, it may be said that the data presented in the tables show how the average yields for any given period may vary as compared with those of another period and that the crop-producing power of our soils, taking the country as a whole, during the last forty years has not decreased. The explanations given above are not complete, as they suggest only briefly in what ways different factors may be active. The campaign of agricultural education, continuously carried on by this department, the agricultural experiment stations, agricultural colleges, and other means of agricultural instruction, has for its object the improvement of agricultural conditions in general, and this is largely brought about by increasing or at least maintaining the crop-producing power of the land. In reviewing results, however, it is impossible to say exactly how much credit is to be given to each factor, as data are not to be found from which such conclusions might safely be drawn. Further, the variation of the average yields between different periods can not be interpreted as meaning a corresponding decrease or increase in the amount of available plant food present in the soil.

During the past decade the American farmer has been stimulated and encouraged by generally favorable weather and rising prices for farm products. At the same time he has had the aid of a system of agricultural education and research, organized under national and state auspices, which for the first time in the history of this country has become widely diffused and broadly efficient. Agriculture under these conditions has rapidly improved and become a hopeful and progressive industry. The problem now is to diffuse agricultural education so thoroughly and effectively that the great mass of our farmers will be able, even under more adverse conditions, to more than hold their own in the world's competition and maintain unimpaired the fertility of our soil for the benefit of succeeding generations.

THE CONSERVATION OF THE FERTILITY OF THE SOIL.

By Dr. H. W. Wiley,
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In compliance with the request of the President of the United States, I offer to the commission appointed for the conservation of our natural resources the following observations upon the conservation and increase of the fertility of the soil.

This is a problem which has from the earliest times been of interest to all persons connected with agriculture. In 1788 the Philadelphia Society for Protecting Agriculture, recognizing the importance of this problem, took steps to secure a proper discussion of it. This society offered premiums for the discussion of certain problems relating to agriculture, among which I may mention the following:

> III. For the best method of counteracting the injurious effects of frost, in heaving or spewing up ground and exposing roots of wheat to the drying winds of the spring, founded in experience, a gold medal, and for the second best a silver medal. The account to be presented to the society by the 20th of December next.
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> V. For the best method of recovering worn-out fields to a more hearty state, within the power of common farmers, without dear or far-fetched manures; but, by judicious culture, and the application of materials common to the generality of farmers, founded in experience, a gold medal; and for the second best a silver medal. To be produced by the 20th of December, 1788.
>
> VI. For the best experiment, soil and other circumstances considered, in trench plowing, not less than 10 inches deep, and account of the effects thereof, already made or to be made, on not less than one acre, a gold medal; and for the second best a silver medal. To be pro[illegible]ed by the 20th of December, 1789.
>
> VII. For the greatest quantity and variety of good manure, collected in one year, and best managed, from materials common to most farms, regard to be had to the proportion and goodness of such manure, and the quantity and goodness of the arable and grass lands of the whole farm on which it is obtained, a gold medal; and for the second best a silver medal. To be claimed by the 20th of December, 1789.
>
> XI. For the greatest quantity of ground, well fenced, in locust trees, or poles of the sort used for posts and trunnels, growing in 1789, from seed sown after this time, not less than one acre, nor fewer than 1,500 per acre, a gold medal; for the second best, a silver medal. To be claimed in December, 1789.
>
> XIV. For the best method, within the power of common farmers, of recovering old gullied fields to a hearty state, and such uniformity or evenness of surface as will again render them fit for tillage; or, where the gullies are so deep and numerous as to render such recovery impracticable, for the best method of improving them, by planting trees or otherwise, so as to yield the improver a reasonable profit for his expenses therein, founded on experiment, a gold medal; and for the next best a silver medal. To be produced by the 1st of January, 1790.

From the above list of problems submitted for discussion it will be seen that the importance of the conservation and increase of the fertility of the soil was thoroughly recognized at that epoch. The prospectus stating the problems to be discussed was issued by the society over the signature of its secretary, Samuel P. Griffitts, on the 5th of February, 1788. The prospectus was published in the Columbian Magazine for February, 1788. I have not yet been able to find any printed copies of the answers to these problems, although I am still on the lookout for them. It would be of the greatest interest at the present time if the views which were entertained immediately subsequent to the Revolutionary war on this important subject could be considered, and later on I have given a summary of them. In the further consideration of this subject I will first call attention to the problem of washed soils.

In 1894 I embodied in Farmers' Bulletin No. 20, in collaboration with the divisions of Soils, Forestry, and Botany, my ideas of the best methods of recovering washed soils. The part which I contributed en bloc is found on pages 7–11, which is as follows:

> Along the banks of the Ohio River and in very many portions of the South hundreds of fields that were once covered with sturdy forests of oak, maple, walnut, and pine, and which bore under cultivation, after being cleared of the natural growth, large crops of wheat, maize, tobacco, and cotton, may now be seen furrowed with gullies as with the wrinkles of age, and abandoned to brush and briers.
>
> A surface layer of good agricultural soil 6 inches deep resulting from the slow and gradual disintegration and decay of rocks and accumulation of humus may have required hundreds of years for its natural formation, and yet it is liable to be washed away in a single storm.
>
> This excessive erosion, or washing, of lands may be prevented, and the already gullied fields may be recovered, and steep slopes of loose material may be held and prevented from washing—
>
> (1) *By chemical means*, in the application of manures and fertilizers and in the accumulation of organic matter, which change the texture of the soil and make it more porous and more absorbent of water, so that there is less to run off over the surface.
>
> (2) *By means of cultivation and underdrainage*, which prevent erosion by distributing the surface flow over the ground and increase the amount carried off by underdrainage.
>
> (3) *By reforestation*, or the planting of trees, which act mechanically to prevent washing.
>
> (4) *By grass and similar vegetation*, which bind the soil grains and prevent their washing away.
>
> The erosion of a soil is caused by the wearing of the rain and snow waters which can not penetrate into the soil fast enough to be carried away by underdrainage, and which, by reason of the slope or contour of the land, run off over the surface, carrying along particles of sand and clay. When this water accumulates in a depression in the field the force of the torrent may be sufficient to cut out a great gully in a short space of time.
>
> The extent of washing to which the soil is exposed depends upon the quantity of rainfall in a given time, the slope or contour of the surface, the texture of the soil, the vegetative covering of the surface, and the kind and condition of cultivation. A soil composed chiefly of moderately coarse grains of sand, and having good underdrainage, will absorb the heaviest rainfall without much danger of surface erosion. A clay soil, on the other hand, into which the water can not percolate with anything like the rapidity of the precipitation will be washed and gullied by the torrent of water which must flow over the surface.
>
> ### CHEMICAL RELATIONS OF THE SOIL TO SURFACE WASHING.
>
> It has been repeatedly shown by experiments and by the experiences of farmers that a soil, as a rule, absorbs water more readily as the content of organic matter and of humus increases. Surface erosion can, therefore, be largely prevented by such a system of cultivation and cropping as will introduce as large a quantity of organic matter into the soil as possible. A very old method

> of recovering washed and gullied land is to place straw in the furrows while plowing, the straw not only acting mechanically to hold the soil in place and prevent surface erosion, but also in a very efficient way to increase the quantity of humus, thus making the soil hold large quantities of water which otherwise would have passed off over the surface. In this simple way fields which have been badly washed and gullied and entirely abandoned may be recovered and made highly productive.
>
> The most important thing in the recovery of waste fields is the incorporation of organic matter of some kind in the soil; pea vines, stubble, briers, or leaves from the forest may be used as a source of the organic matter. The straw from one acre of land which has been recovered, as mentioned above, will be sufficient to start the recovery of another acre, even if this be deeply furrowed with gullies. Where enough organic matter can be used as a surface dressing, this layer helps greatly to retain water and to make the underlying soil more absorbent.
>
> As soon as a sufficient supply of humus has been accumulated and the lands are brought up to an adequate condition of fertility, clover or grass should be seeded, if the land is at all suited to these crops, or rye, oats, or field peas should be sown to help hold the surface. Little by little, but more rapidly than would be expected from the forbidding aspect of the field, the land can be reclaimed again and made productive through the accumulation of humus and organic matter. A soil containing a fair quantity of humus will wash less readily than one nearly destitute of this matter.
>
> A soil containing a fair supply of lime is much less liable to wash than one similarly situated and exposed which is deficient in lime. The reason of this is that clays which are deficient in lime, when once brought into suspension by moving waters, will remain in suspension and keep the water turbid for a long time. Clays which are heavily impregnated with lime salts, on the other hand, are in a flocculated state, the fine grains of clay being held together and in contact with the larger grains of sand. This flocculated mass quickly settles and is originally not so easily disturbed and carried off by moving water. A field treated with an abundance of lime is thus less easily washed by heavy rains. The results of investigations by Schulze, Schloesing, and Hilgard have shown in a most emphatic way the beneficial changes which take place, especially in stiff clay soils, by the application of lime.
>
> The change in the physical condition of the soil which is produced by the lime, and which is likewise produced by a number of other chemicals ordinarily used in commercial fertilizers, is another important factor worthy of consideration. A stiff clay soil is practically impervious to the penetration of surface water when it is delivered in such torrents as we are liable to have in our summer storms. A well-limed soil, on the contrary, although it may contain as much clay but in which the particles are flocculated or drawn together, is much more pervious to water, and the amount of water which the soil will carry down through underdrainage is increased, and the excess which has to flow off over the surface is diminished. The surface washing of cultivated fields, especially those which are naturally deficient in lime, can be greatly diminished, therefore, by the free application of this substance to them.
>
> A number of the ordinary fertilizing materials have an important effect upon the texture of soils and upon the permeability of soils to water, but few systematic investigations have been carried on in this line and not much, except of local importance, has been definitely settled by experiments or by the experiences of farmers.

From the above it is seen that the problem of washing may be partly controlled at least by the chemical treatment of the soil in such a manner as to render the particles more adherent and tenacious and less liable to disintegration under the action of rain. The tendency to wash may also be largely overcome, except in case of excessive rainfall, by deeper tillage. If the hard underlayer of the soil on the hillside could be broken and softened to the depth of from 12 to 18 inches the quantity of water which would be retained by the soil before starting to run would be greatly increased and thus the amount of washing would be to that extent diminished. Only those who have lived in localities in which the soils are subject to washing, as I have, can realize the great importance of making efforts to counteract it. The methods of holding the soil by grass and by various trees are, of course, the most effective, but these take the soil away from tillage and thus, to a certain extent, restrict the farmer's activities in the growth of ordinary field crops. The contour method of tillage is also a great aid in this respect, and it should always be resorted to in connection with chemical and mechanical means of avoiding erosion. By careful attention to details of this kind it is easy to see that large areas may be restored to tillage which have been virtually abandoned and allowed to grow up in brush and briars.

In an address delivered before the American Association for the Advancement of Science, Section C, in 1886, I discussed the economical aspects of agricultural chemistry. This discussion was largely in the line of the conservation of plant food, which was made the subject of another discussion at a later period, as I shall mention further on. Without attempting to recapitulate here the statistical data on which the argument is based, I will call attention to some of the principal conclusions reached in this discussion. It was shown that the total value of plant food—that is, potash, phosphoric acid, and nitrogen—removed from the soil in the agricultural crops of the United States at that period had a market value of three and one-third billion dollars. Of course the market value at the present time has increased not only in proportion to the crops but also in actual cash value for the ingredients mentioned. In commenting upon this point I said:

> These quantities of plant food removed from the soil annually seem enormous, but it must be remembered that they are not all lost; much of them is left in the soil, in roots, straw, stalks, etc. Those, however, who are acquainted with the method of farming practiced in the newer parts of our country know that cornstalks and straw are generally regarded as nuisances, to be removed as easily and speedily as possible. It is not tilling the soil, but killing it, that is practiced. Stables are removed to get out of the way of the accumulating manure, and the cornstalks are raked together and burned to prepare the field for a new crop. True, in many localities the waste of such a proceeding, especially in nitrogen, is understood. Yet it must be confessed that over vast areas of our agricultural lands there is no conception of the idea of possible exhaustion of the soil, and no systematic method of preventing it. The refuse of the crop, the straw, the stalks, etc., are put out of the way as easily and quickly as possible, and without thinking of the robbery which is thereby committed.
>
> The stores of plant food which have accumulated in our virgin soils are indeed great, but they can not withstand this constant drain on them. The effects of this system of culture soon show themselves in diminished yield, as is seen in the great wheat fields of the Northwest and of California, which do not produce at the present time more than half the crop at first obtained from them.

It is interesting to note that at that time, in 1886, long before the discovery of the rôle of leguminous plants in producing nitrification, the importance of this process was fully realized in agriculture. I say on page 21:

> It would not be proper to take time here to enter into a detailed discussion of the process by which organic nitrogen, or nitrogen of any kind, is converted into nitric compounds, a process which is of the utmost importance to vegetable growth and which it is now generally conceded is due to a kind of fermentation set up by a special organism. Thanks to the results of the patient and fruitful investigations of Pasteur, it has been possible to secure pure cultivations of this nitric ferment. Perhaps the chief credit of this achievement is due to Schlosing and Muntz,[a] but the part taken in it by Warrington, Berthelot, Deherain, and Joulie must not be forgotten.

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[a] Comptes rendus, Vol. LXXXIV, pp. 301 et seq., and Vol. LXXXIX, pp. 891 et seq. and 1074 et seq.

The dangers which were to be apprehended from denitrification were also fully set forth at that time, as will be seen by the following quotation:

> A process directly the reverse of nitrification has also been observed by Gayon and Dupetit,[a] by which nitrates are destroyed by a denitrifying ferment. This ferment is described as an anaerobe. It acts most vigorously at a temperature of from 35 degrees to 40 degrees, and the experimenters, under favorable conditions, succeeded in totally decomposing a 5 per cent solution of nitrate of potassium. Heat, chloroform, or sulphate of copper sterilized the solutions; but carbolic and salicylic acids do not interfere with the fermentation, on the contrary, are themselves decomposed, like organic matters. The gas evolved is pure nitrogen, representing a large portion of the nitrogen originally present in the nitrate. The rest of it forms ammoniacal compounds.[b]

Again, on page 32, I say:

> In the light of the investigations of the last few years it may be well to admit that the opinion held by the vast majority of agronomists and agricultural chemists and physiologists, that the free nitrogen of the atmosphere never is assimilated by the growing plant, should be held open for revision.
>
> The general belief among scientific men who have paid attention to this matter has inclined to the opinion of Lawes and Gilbert, Pugh, and Boussingault that the growing plant does not in any circumstances assimilate the free nitrogen of the air. So widespread was this opinion that before the investigations just noticed, when Atwater[c] published a series of experiments showing the contrary, it was thought some factor in the investigation had been overlooked. According to Atwater's results it appears that "the plants grown in nutritive solutions exposed to the air, but protected from rain and dew, contained at maturity much more nitrogen than was supplied them in nutritive solution and seed."
>
> This is certainly a definite and unequivocal statement, and it was followed by "for this excess of nitrogen there was but one possible source, namely, the atmosphere."

All these elements in the conservation of the plant foods in the soil naturally must be construed in connection with the food supply of man himself, and this led to the following observation in the paper read in 1886, as follows:

> Since with a proper economy the natural supplies of potash and phosphoric acid, as we have seen, may be made to do duty over and over again and last indefinitely, the economist who looks to the welfare of the future need have no fear of the failure of these resources of the growing plant. Indeed, it may be said that the available quantities of them may be increased by a wise practice of agriculture based on the teachings of agricultural chemistry.
>
> But with the increase of population comes an increased demand for food, and therefore the stores of available nitrogen must be enlarged to supply the demands of the increased agricultural product. It is certain that, with the new analytical methods and the new questions raised by the investigations of which I have spoken, many series of experiments will be undertaken, the outcome of which will definitely settle the question of the entrance of free nitrogen into vegetable tissues. If this question be answered affirmatively, agricultural science will not place bounds to the possible production of foods. If the nitrifying process does go on within the cells of plants, and if living organisms do fix free nitrogen in the soil in a form in which at least a portion of it may be nitrified, we may expect to see the quantities of combined nitrogen increase pari passu with the needs of plant life.
>
> Thus even intensive culture may leave the gardens and spread over the fields, and the quantities of food suitable for the sustenance of the human

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[a] Comptes rendus, Vol. XCV, pp. 644 et seq.

[b] Gayon and Dupetit report the latest results of their investigations of the denitrifying ferment in the Journal de Pharmacie et de Chimié, July, 1886, pp. 34, 35.

[c] Am. Chem. Jour., Vol. VI, pp. 365 et seq.

race be enormously increased. In regarding the agricultural economies of the future, however, it must not be forgotten that a certain degree of warmth is as necessary to plant development as potash, phosphoric acid, and nitrogen.

If it be true, therefore, that the earth is gradually cooling there may come a time when a cosmic athermacy may cause the famine which scientific agriculture will have prevented.

Fortunately, however, for the human race, the cereals, the best single article of food, are peculiarly suitable to a cold climate. Barley is cultivated in Iceland, and oatmeal feeds the best brain and muscle of the world in the high latitudes of Europe.

It is probably true that all life, vegetable and animal, had its origin in the boreal circumpolar regions. Life has already been pushed half-way to the equator, and slowly but surely the armies of ice advance their lines. The march of the human race equatorwards is a forced march, even if it be no more than a millimeter in a millennium.

Some time in the remote future the last man will reach the equator. There, with the mocking disk of the sun in the zenith, denying him warmth, flatheaded and pinched as to every feature, he will gulp his last mite of albuminoids in his oatmeal, and close his struggle with an indurate inhospitality.

The waste and conservation of plant food was studied in a systematic manner as applied to soil fertility in my address as retiring president of the American Chemical Society at the Baltimore meeting of the Society on December 27, 1893. The problem which was presented at that time was stated in the following language:

One of the greatest of the practical problems presented for solution by agricultural chemistry is the conservation of plant food. With an abundance of plant food and a favoring climate, it is difficult to place a limit to the power of the earth for supporting life. We have read much in political economy of the limit of subsistence, and one bold philosopher has based a theory of the limitation of the number of human beings upon the earth on the insufficiency of the earth to support a greater number. Happily, however, the Malthusian philosophy was promulgated before the days of that great agricultural renaissance which has been brought about chiefly through the efforts of experimental agricultural chemistry. I am not so blinded by the achievements of agricultural chemistry as to deny to many other branches of science an important and, in many cases, necessary influence in this development of agricultural science; but I think every candid man will admit that in this development chemistry has always taken the front rank and led the way. This is preeminently true of the investigations into the nature and extent of the plant food available on the surface of the earth. In this country, owing to the great stores of wealth which the past had accumulated in the soil, it is only within recent years that the question of the supply of plant food has assumed any practical importance. As long as there were virgin fields at the disposal of the agricultural rapist, the conservation and restoration of exhausted fields were of little consequence. The result has been that the wealth of hundreds or, perhaps, thousands of years slowly stored in the soil has been poured forth in a century, not only for the enrichment of this country, but for the benefit of all countries. Unfortunately or fortunately these stores are now practically explored and there is little left in this land of virgin fertility to tempt the farmer to new conquests. Not only have these stores of plant food been utilized but, much to the discredit of the American farmer, they have been wasted. The mark of good agriculture is to see fields yielding annually good returns and increasing or at least not lessening in fertility. This being true, the history of American agriculture to within a few years must be the history of bad farming, for everywhere we have seen fertile fields losing their fertility and farms once productive abandoned. No difference how great the store may be, if it be continually drawn upon and never replenished, the day will some time come when it will be exhausted. This day has come to a large portion of the agricultural lands of this country and to-day there is an awakening everywhere in regard to the best methods of checking the waste and of restoring what has been lost.

I desire for a brief period on this occasion to call the attention of the chemists of this country to some of the methods by which plant food is removed from the fields and some of the direct and indirect ways in which it is and may be returned. On a former occasion[a] I have discussed the extent to which plant food is removed from the soil directly in the crops and the dangers which arise to an agricultural community which continually exports its agricultural products. On that occasion I pointed out the amount of potash, phosphoric acid, and nitrogen per acre annually removed by the crops of the United States, and showed that the only safe agricultural products to send out of a country were sugar, oil, and cotton. It is true that with native, unexhausted soils a country may acquire great wealth by agricultural exports, but the history of the world shows that a country which depends for its wealth and its commerce on agricultural exportation is in the end reduced to pauperism. A single example may serve to accentuate this remark; I refer to the island of Cyprus, which two thousand years ago was the granary of many cities bordering on the Mediterranean Sea. Supplying hundreds of thousands of people with corn, it gradually became impoverished, and to-day its soils are perhaps the poorest of any known.

The waste to which I desire to call your attention to-day is not that which normally takes place in the production of a crop, but that which is incidental to the cultivation of the soil and to a certain extent unavoidable. My purpose is to develop, if it be possible, the relations of agricultural chemistry to this waste, with the purpose of pointing out a course by which it can be returned and in what way we may at least reduce to a minimum the unavoidable removal of valuable plant food. You have all, perhaps, surmised the character of this waste; I refer to the denudation of fields by water and to the removal of soluble plant food by the percolation of water through the soil.

The losses due to the denudation of fields are purely of a mechanical character. The natural forest, or the natural covering of grass over an area of soil, prevents, to a large extent, the denudation due to heavy downpours of rain. The removal of the forest and the destruction of the grass by cultivation leave the soil in a condition in which it is unable to resist the action of flowing surface water. The muddy character of the water in all streams bordering on cultivated hilly fields after a heavy rain storm is a familiar instance of the tremendous energies which are exerted by a heavy downpour of rain in the carrying of the soil into the streams and its transportation toward the sea.

It is not necessary to emphasize the fact that the agricultural chemist is practically powerless to prevent the surface erosion due to heavy rains, but a few practical lessons derived from the application of chemical discoveries to the soils show how, in a certain measure, even surface erosion may be controlled, or at least reduced to a minimum, by the application of the principles of culture founded upon the facts disclosed by advanced science.

The observing agriculturist will have noticed that even in a hilly country a soil in situ underlain by limestone is less likely to be cut up by gullies than a soil similarly situated and deficient in carbonate of lime. The reason of this is plain. In a soil deficient in lime the clays when once brought into suspension by moving water assume a semicolloid state and remain indefinitely in suspension. Clays, on the other hand, which are heavily impregnated with lime salts are in a flocculated state, and the larger aggregates thus produced settle quickly. The result of this is that such a soil is less easily moved by water and a field thus treated less exposed to washing by heavy rains.

The change in the physical condition of the soil which is produced by the lime is also another important factor worthy of consideration. A stiff clay soil is almost impervious to the penetration of surface water, and thus the amount which is carried off is raised to a maximum. A well-limed soil, on the contrary, in which the particles are perfectly flocculated, is much more pervious, and the amount of water which will be retained and delivered gradually to vegetable growth is much greater. Thus the beneficial effects of lime are manifested in both ways—in the better retention of the flocculated clays and in increasing the capacity of the soil for holding a given amount of water in its interstitial spaces.

There are many other salts which also have the same properties as those of lime, but I have spoken of lime salts chiefly because they are cheaper and therefore more economically applied. Perhaps, next to lime, common salt would be the most efficient in producing the results already described; but common salt, being extremely soluble, would soon be leached out of a soil. On the other hand, lime, even when supplied as hydrate, in which case it is somewhat soluble, quickly becomes converted into a carbonate which is practically insoluble in water which does not contain an excess of carbon dioxide.

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[a] Vice-presidential address before the American Association for the Advancement of Science, Buffalo, 1886.

I am aware of the fact that liming to prevent erosion by surface drainage has not been emphasized as an example of the benefit of the proper chemical treatment of soils, yet I feel sure that all who will give the subject a thoughtful consideration will agree with me in saying that this aspect of the subject is one of no small importance, especially when considered in respect of hilly fields, and even of fields of more level surface.

Without dwelling long upon this point, it is only necessary to call your attention to the immense quantities of soil material annually conveyed to the sea by the causes of erosion already mentioned to show what an active and powerful foe the farmer has in this source of loss. Any one who watches, even for a short time, the volume of water carried by the Mississippi into the Gulf of Mexico will have a most effective object lesson in regard to this source of loss.

A more striking lesson may be seen in the hill regions bordering both banks of the Ohio River. Hundreds of fields once covered with sturdy forests of oak, maple, and walnut, and afterwards bearing large crops of maize, tobacco, and wheat, may now be seen furrowed with gullies, as with the wrinkles of age, and abandoned to brush and briers. The same is doubtless true of other hill regions, but I speak the more advisedly of those which have come under my personal observation.

Great, however, as the mechanical loss of plant food is, it is by no means as dangerous as the loss of the soluble materials caused by the percolation of the water through the soil. The study of the nature of the loss of these soluble materials, together with the estimation of their amount, forms the subject of lysimetry. Agricultural chemists have used many devices for the purpose of determining the character and amount of the natural drainage of soils. Evidently the treatment of a specially prepared portion of soil by any solvent, although giving interesting results, does not indicate the natural course of solution. The only way in which this can be determined is to be able to collect, measure, and study the character of the drainage from a given portion of the arable surface of the earth in situ and under normal conditions. Various methods of lysimetric investigation have been proposed and used, all of them possessing many points of value.

This paper discussed not only the sources of loss of plant foods, but also the methods by which the lost plant food may be recovered and restored. Special chapters are given to the conservation of nitrogen and the increase in its quantity; to the potash deposits and the likelihood of discovering additional deposits to those which are found in Germany; also to the question of phosphoric acid and its increased supply. The progress of the soluble plant foods from the time they are leached from the soil until they are carried into the ocean is traced, and also the methods by which they may be restored to the use of man. The conclusions derived from this study are as follows:

From the foregoing summary of the methods of waste of plant food it has been seen that in spite of all the precautions of the farmer and the chemist, and in spite of the selective absorption of the soil, immense quantities of valuable plant food are carried into the sea, where apparently they are lost to agriculture forever. But this is only an apparent loss. The economies of nature are so happily adjusted as to provide a means of gradually returning in some form or other to the power of the farmer the plant food which has been apparently destroyed. It is true that this return will probably not be to the locality where the waste originally occurred, and it may not take place until after the lapse of thousands of years, but this is of no consequence. Provided arable lands in general receive in some way and at some time a certain return for the plant food removed, it is entirely immaterial whether this be the original plant food removed or other equally as good.

The sea is the great sorting ground into which all this waste material is poured. The roller processes of nature, like the mills of the gods, grind exceedingly slow and small, and the sea becomes the bolting cloth by which the products of milling are separated and sorted out. As soon as this waste material is poured into the sea, the process of sorting at once begins. The carbonate of lime becomes deposited in vast layers, or by organic life is transformed into immense coral formations or into shells. Phosphoric acid is likewise sifted out into phosphatic deposits or passes into the organic life of the sea. Even the potash, soluble as it is, becomes collected into mineral aggregates or passes into animal or vegetable growth. All these valuable materials are thus conserved and put into a shape in which they may be returned sooner or later to the use of man. In the great cosmic economy there is no such thing as escape from usefulness of any valuable material.

In these papers I did not take up the possibilities of increasing the food supply of plants by the action of leguminous crops, nor by the modern method of producing nitric acid directly in merchantable quantities by electrical discharges through confined portions of air; nor did I naturally refer to the vast deposits of phosphates which have been discovered in this country since the date of the papers cited, or to the possibilities of increasing our quantities of potash through the direct utilization of felspar rich in that material. These matters, however, are of such importance in this connection as to merit their extensive consideration.

EARLY STUDIES OF SOIL FERTILITY AND EXHAUSTION.

The exhaustion of the soil, to which reference has already been made, is a fact which was recognized and deplored by the earliest writers on agriculture in the United States. The methods of recuperating exhausted soil were also well understood in the early history of agriculture in this country, due to the fact that the methods used in old agricultural countries were well known by the immigrants. An essay was read before the Philadelphia Society for Promoting Agriculture, on September 28, 1786, by Mr. George Morgan, of Princeton, N. J. This was in competition for one of the prizes offered for the best plan of arranging a farmyard. This essay was devoted largely to the methods of collecting and utilizing the manure. In speaking of the importance of collecting farm manure for its fermentation, he says:

> The earlier it is done the better. But it must be piled so high as that the cattle can not mount on the heaps, and care taken to mix the rich earths, mud, and marl well with the dung and litter. And if, after the first heaps remain a fortnight or a month, they can be turned over, or two heaps be thrown into one to occasion a new fermentation, the dung will be improved. When dung and litter are thrown into heaps without earth, they not only heat, but burn, and thereby suffer great injury in quality and quantity. After the heat has subsided the fermentation is over. If, when heaping your dung, lime can be procured, that is the time to add it in as large a quantity as you can command; but my situation is too remote from limestone to have this benefit.
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> By the time the whole is thus heaped, that first done will have undergone the proper degree of fermentation for carting out upon your Indian corn, potato, and turnip grounds, which I suppose to have been plowed twice or thrice. My aim is to spread and plow in 40 loads of 20 bushels each per acre; and, with the stock mentioned above, I can manure at this rate from 15 to 20 acres (according to the proportion of rich earths I cart in) every year. My calculation is about 200 loads of marl or rich earth as a foundation for my barnyard. I wish I could make it double that quantity. Gentlemen who have viewed my heaps of dung and my barnyard may form a judgment whether the quantity I mention is exaggerated.
>
> The objections made to my method by common farmers are the expense and trouble of it; yet they allow every load of my manure, without lime, to be worth half a dollar on the spot, whereas it does not cost me one-third of that sum.
>
> The attentive farmer need not be told to dig and wall a receptacle for the juices of his barnyard and to pump them over his dung heaps or carry them onto his grass. He will recollect and practice every means of benefiting his manure. The best method of constructing such a receptacle is particularly described and recommended by the agricultural society at Manchester. As I have not yet built one myself, I beg leave to refer to their directions.

The first premium granted by the society was for this essay, they having adjudged to Mr. George Morgan a gold medal, "The first premium granted by the society, as an evidence of the sense they entertained of the merit of his essay."

One of the earliest experiments in this country in the rotation of crops was that conducted under the auspices of the Philadelphia Society for the Promotion of Agriculture, by a Jersey husbandman, and printed in the Columbian Magazine, April, 1787. The scheme for promoting the increase of crops is as follows:

> I have also laid out a field for a course of crops as practiced in England; it contains 12 acres, laid out, but not fenced off, in 3 acres each. The last harvest it stood in rye, and this autumn it has been plowed deep—some of it trenched. The following course is intended: Lot No. 1, to be manured next spring and sowed with barley; when up, to be sowed with 12 pounds of clover per acre and rolled in. No. 2, oats. Nos. 3 and 4, to be fallowed. The succession will stand as follows:

Year.	No. 1.	No. 2.	No. 3.	No. 4.
1786	Barley	Oats	Fallow	Fallow.
1787	Clover	Barley	Oats	Wheat.
1788	Wheat	Clover	Barley	Oats.
1789	Oats	Wheat	Clover	Barley.

> And thus to continue in a succession of four crops, the stubbles always to be plowed up deep in the fall and laid in three-pace lands, and the barley land to be manured in the fall or spring before plowing and sowed with clover, as above.
>
> It would surprise an European to hear that the average produce of our wheat crops in this neighborhood is under 6 bushels; our farms are laid out in four or five fields, broken up with oats, corn, and a great deal of buckwheat; next year fallowed; third year in winter grain; fourth year in grass, and some also the fifth year. This course leaves little pasture till the stubbles and meadows are opened, by which little manure can be made. No wonder, then, that our crops are light with such constant tillage and scarce any help. The grain has not strength to stand the cold springs; much of it heaves out or is blown away with the March winds.

It is evident from the above that the system of cropping at that period was such as to favor the production of very little manure, and thus to progressively exhaust the soils.

The same author says further on:

> I am also convinced that deep plowing, if not trench plowing, will be advantageous in lands much worn out by tillage without help of manure.

His further advice for improving worn-out soils was:

> Besides breaking up in the fall, deep plowing and drilling, making composts of various materials, and green dressing with buckwheat should not be neglected; also liming where convenient.

In a work entitled "Arator," a series of agricultural essays, written by John Taylor, a citizen of Virginia, in 1813, it is stated, in speaking of the most effectual methods of fertilizing:

> Manures are mineral, vegetable, or atmospherical. Perhaps the two last may be resolvable into one. Mineral manures are local and hard of access. But the earth swims in atmosphere and inhales its refreshments. The vegetable world covers the earth and is the visible agent to which its surface is indebted for fertility. If the vast ocean of atmosphere is the treasury of vegetable food, vegetable manure is obviously inexhaustible.

This early prophecy of the neutralization of the atmosphere as a source of plant food has been verified by the progress of science, which shows that the carbon dioxid with water and the nitrogen of the atmosphere are all abundantly used as sources of plant food. Again the author says:

> It is yet a question whether the earth is enriched by any species of manure except the vegetable or atmospherical; and experiments have hitherto leaned toward the negative. Without new accessions of vegetable matter, successive heavy dressings with lime, gypsum, and even marl have been frequently found to terminate in impoverishment. Hence it is inferred that minerals operate as an excitement only to the manure furnished by the atmosphere. From this fact results the impossibility of renovating an exhausted soil by resorting to fossils, which will expel the poor remnant of life, and, indeed, it is hardly probable that divine wisdom has lodged in the bowels of the earth manure necessary for its surface.

The utility of red clover as a source of securing atmospheric fertilization was also fully recognized:

> To draw from the atmosphere the greatest quantity of manure, to check the loss the earth sustains from evaporation during the process by shade, to give the manure the most lasting form, and to deposit it in the most beneficial manner are primary objects of the inclosing system.
>
> The best agent known to us for effecting the three first is the red clover. Its growth is rapid; its quantity exceeds the product of any other grass: it throws up a succession of stems in the same summer; and these stems are more solid and lasting than those of other grasses. These successive growths constitute so many distinct drafts from the great treasury of atmospherical manure in one year. Whilst these drafts are repeated, the clover is daily securing the treasure, in a form able long to elude the robber evaporation, which it also opposes by shade. To its extracting from the atmosphere the greatest quantity of manure and elaborating it into a lasting form the most suddenly of any other vegetable cover, clover lays for wheat are indebted for their fame. Their success has been attributed to the portion of the vegetable in a succulent state, whilst it was owing to the greater portion which had arrived to maturity previous to the fallow. To ascertain this fact, let one moiety of a clover field be turned in as soon as its first crop flowers, and the other after the stem of the last crop is hard, and the whole sown on one day in wheat.
>
> The peculiar propensity of clover to be improved by a top dressing of the gypsum is another striking circumstance of its affinity to the system for fertilizing land by its own cover. As its growth is suddenly and vastly increased by this top dressing, it furnishes reason to believe that the effect flows from a disposition communicated by the gypsum to the clover for imbibing atmospherical food by its external parts; and so much as it thus gains affords to the earth a double benefit. One, that this food, not being extracted from the stock of atmospherical manure possessed by the earth, does not impoverish it; the other, that being bestowed on the earth from whence it was not taken it adds to its fertility.

In regard to the sources of artificial manure he states as follows:

> The most abundant sources for artificial manure in the most exhausted district of our country are the offal of Indian corn, the straw of small grain, and the dung of animals. We find in the two first proofs of the value of dry vegetables as a manure. If these few means for fertilizing the country were skillfully used, they would of themselves suffice to change its state from sterility to fruitfulness; but they are so egregiously neglected or mismanaged that we hardly reap a tithe of their value.
>
> There is no farinaceous plant which furnishes so rich and so plentiful a crop as the Indian corn. It yields food in abundance for men, beast, and land. By the litter of Indian corn and of small grain, and by penning cattle, managed with only an inferior degree of skill, in union with inclosing, I will venture to affirm that a farm may in ten years be made to double its produce and in twenty to quadruple it; the ratio of its increased value is, of course, still greater.
>
> There is no other secret in the business than that none of these manures be wasted. The agriculturist who expects to reap good crops from neglecting his manures is equally a fanatic with the religionist who expects heaven from neglecting his morals.

In regard to the combination of manures the author says:

> Gypsum, clover, and inclosing, working in conjunction, have within my own knowledge doubled, trebled, and in a very favorable soil quadrupled the value of land in the space of twelve or fifteen years; whilst the land regularly produced two exhaustive crops—those of corn and wheat—in every four years of the period, and these crops were continually increasing.
>
> Of lime and marl we have an abundance, but experience does not entitle me to say anything of either. About a family, a variety of manures may be thrown together and form a small store for gardens and lots. Among these, ashes deserve particular attention. Like other manures, they suffer by exposure and evaporation, but less, because water is a menstruum which will convey much of their salts into the earth if they are spread; the same menstruum conveys most of these salts out of the ashes if they are exposed to it before they are applied as a manure. Hence, when ashes have not been reduced by water in richness they are to be used as a manure more sparingly; and when they have, more copiously. In their unreduced state just from the chimney, when sprinkled an inch thick on the long litter and dung from a recently cleansed stable, they constitute the best manure I have ever tried for asparagus. The beds are well forked up in the fall, covered two or three inches deep with the unrotted stable manure on which the fresh ashes are placed, and so remain until they are thrown into proper order in the spring.

The effect of tobacco on the land is graphically described by the author in the following words:

> Though its profit is small or nothing, its quality of starving everything exceeds that of any other crop. It starves the earth by producing but little litter, and it starves its cultivators by producing nothing to eat. Whatever plenty or splendor it may bestow on its owner, the soil it feeds on must necessarily become cadaverous and its cultivators squalid. Nor can it possibly diffuse over the face of the earth or the faces of its inhabitants the exuberance which flows from fertilization nor the happiness which flows from plenty.

The first account I can find in this country of the use of marl as a fertilizer is in a letter read before the Philadelphia Society for Promoting Agriculture on December 9, 1806. The letter was written by Josiah Reeve, of Rancocas Creek, on the 20th of November, 1806. It is called a "new mineral manure for clover." Mr. Reeve describes the manure as follows:

> The black sulphuric substance by us called marl is found in great abundance through most parts of the country in a northeast and southwest direction from the headwaters of Crosswick's Creek, in Burlington County along on the upper part of nearly all the creeks from thence to the southern part of Gloucester County; we find it in the banks of streams and in most places at the bottom of many of our wells, and it often spoils the water. On my farm and through our neighborhood it abounds near the surface in the meadows and generally in the banks or hillsides, about from 4 to 6 feet below the surface; the depth I can not, from experience, say much about, but from the observations of others find it varies from 6 to 15 feet and more. I have at thy request brought with me to the city for thy use a box of it, of which I wish thee or thy friends to make a chemical analysis. The result of my own and my neighbor's experience is that for grass lands about 10 two-horse loads to the acre—laid on the surface in the autumn—is better, if the next season proves moist, than double the quantity of any other manure and will last longer, changing in two years rough bound meadow into almost clear white and red clover; but the last dry summer it did very little good. I am in the practice of mixing in my barnyard or in the compost heap the marl with the dung, two loads of the former with one of the latter, and always find when put on my fallow that it is as good, or better, than the same quantity of dung alone, and much better for the clover that follows, but in its crude or raw state does not do on grain the first year, except for Indian corn, which some say it helps by laying it on the tops of the hills in the spring. I put some in my manure for my garden and found it made the clover grow among vegetables so spontaneously that we have had much trouble to destroy it ever since.

The above description shows an admirable use of the marl in composting with barnyard manure, and describes the general effects of this marl upon the soil in England, which is easily recognized as descriptive of the same effects to-day. The use of marl or chalk has been practiced from the earliest antiquity in agriculture. In the north of France I saw a number of deep hollows in the otherwise level fields, and was told by the inhabitants that they were ancient marl beds which were used at the time of the occupancy of Gaul by the Romans. The utility of marl in restoring fertility of the soil consists largely in its neutralizing effects produced by the decay of vegetable matter and by its mechanical effects in percolating clay, and thus rendering the soils more porous and spongy. Its efficacy in promoting the growth of clover, as was seen, was known by our farmers more than one hundred years ago.

Another valuable article on the utilization of lime in the improvement of the soil is found in a letter read to the Philadelphia Society for Promoting Agriculture on December 8, 1807. The letter is so interesting that I give it in full:

IMPROVEMENT OF LAND.

CHESTER COUNTY, *November 20, 1807.*

FRIEND VAUGHAN: Agreeably to your request, I now inform you how I have improved my farm. The first three years I could only keep 2 horses and 2 cows, and seldom had more than 4 tons of hay, though the last six years I have grown from 20 to 25 tons a year. Had I taken your advice when I first took the farm, it would have thrown much in my way—that was, to use lime on my land. When I determined to try it, I first got 200 bushels and laid it on 9 acres, planted with Indian corn, and had as great a crop as had been ever seen growing. My neighbors came far and near to see it. The year after, I made a fallow of the land, put in wheat on 3 acres and the rest in rye, and had a good crop. In the spring I sowed it with clover and timothy and put 2 bushels of plaster of Paris on an acre, and had as great a crop of clover as could grow; it laid three weeks before the time of mowing. The lime and plaster did all this, for no land could be poorer before. There are 10 acres in the field, and not being used to spreading lime I laid it on 9 acres; where I laid no lime I got no clover, although I put on the plaster. I have limed all my land and plastered it every year, and never fail of clover. I think 2 bushels of plaster are enough on 1 acre. In one field I have put on 4 bushels on half and 2 on the other half, and I find no difference in the produce. There is another thing in which I was wrong in not taking your advice, viz, not keeping oxen instead of horses. This spring all my horses became sick, and I was forced to buy a pair of oxen. I supposed I should be tired of them, but, on the contrary, I am tired of horses, as I find that with my 2 oxen I can do more work than I could with 4 horses, and with half the expense. I have worked horses for forty years, and if I had used oxen in their place they would have put £500 in my pocket. My oxen go to the limekiln once a week—21 miles—in the morning, and return the next day, in the afternoon; after resting two hours they go to work; horses can not do this. There is another thing I find advantage in. I cut all my cornstalks and carry them to the barnyard for litter; when well trodden I cover them with lime and then add another layer, then more lime, and so on until all the stalks are used. In the spring the stalks are all rotted, and I have no trouble in turning them up. Last spring I had 176 loads of dung. The first three years if I had 20 or 25 loads it was a great thing. My neighbors thought me crazy to buy lime and to be at such expense, but now they are all falling into the same way.

I plow all my land in the autumn for corn, and in the spring lay on the lime, plow it all over, harrow it down, and never am troubled with cutworms or weeds. I find the fall plowing is a great advantage.

Your affectionate friend,

(Signed) WILLIAM ASHFORD.

JOHN VAUGHAN,
Member Agric. Soc. Philad.

The secretary of the society adds some important comments on the letter, stating, among other things, that it is published "for the encouragement of those who live on worn and exhausted lands." Some of these claimed that they could not procure manure, that plaster was not sufficient, and that lime was expensive. An important point, however, is emphasized, viz, "that the mixing of lime while the vegetable substances are putrefying is a mistake. It had better be put on the land, or if it must be mingled with the manure, let it be after the fermentation is over." This is in exact harmony with the present understanding of the fact that lime frees ammonia and thus produces a loss of valuable nitrogen.

The advice given by the Philadelphia Society for Promoting Agriculture to farmers of worn-out land is so interesting that I give it in full:

1. If no water be in your barnyard, dig a well; and confine your stock from November to May, never permitting them to wander after water, or the provender of the stalk field, in which they empty themselves and scatter their dung, instead of filling themselves, either for profit or economy. Let not a hoof unnecessarily leave your yard.

2. Haul into the yard every putrescible substance you can get, and when proper, clean up the yard, and have a pen for your manure, both from the yard and stables, inaccessible to cattle or horses, whose poaching or treading prevents fermentation and is highly injurious. Mix earth with your litter, rather than lime.

3. Plow your fields in the fall 7 inches deep, but plow no more than you can manure, and let the rest lie waste till you can do it justice. Buy lime; if you can not reach 2 acres be content with 1. Move your fences and plow up their sites. Mix leaves, weeds, and all putrefiable substances in long and low beds, so as to be turned by the plow and become excellent compost. For this purpose also go into your woods and with leaves and wood soil make beds of compost of these materials, as well as of the mold in low places into which it has washed or has been deposited by ponds of water or rains and floods.

4. Lime your fall-plowed fallow with 40 bushels to the acre. Plant Indian corn; put compost on the hills and plaster the corn.

5. After the corn is gathered cut your stalks and haul them to your yard. Plow again for a winter fallow. Your plowing (except for seed) should never be less than 5 to 7 inches deep.

6. In the spring harrow in buckwheat, to be rolled and plowed in when in full blossom with an East Jersey plow without a coulter, or any other that will not choke.

7. Put on what dung you have made and plow it in with your seed. Your compost will now be fit for top dressing your wheat, which is to be the crop of this year; and sow no more than you can manure.

8. On the wheat sow clover seed, and the succeeding spring plaster the clover. All this can be accomplished in two or three years. When you have perfectly learned this alphabet you will get into habits that will enable you to teach instead of requiring instruction.

9. When your old fields have inert vegetable matter (as is the case with most old fields) plaster them to throw up pasture, and increase your stock by this additional subsistence.

10. Never sow in a foul or weedy fallow to save a plowing, or on a wet one to save time. Avoid oats and exhausting crops and never stubble in or let one chaffy-husked or culmiferous crop immediately follow another.

11. Change your crops and destroy weeds, or they will destroy you; turn a foe into a friend by turning them into manure. Explore your own and the neighboring farms for marl, clay, peat, earths, or substances for experiments on your fields. Be not discouraged by failure, but persist in essays on a small scale till you succeed.

The use of lime and its value in preserving and increasing fertility is further illustrated in an article in the Annals of Agriculture and Other Useful Arts, published by Arthur Young, London, volume 2,

1784. This is found in an account of a fortnight's tour in Kent and Essex, page 39:

The circumstance in their husbandry most deserving attention is the use of chalk as a manure. They bring it all from Malden, at the distance of 6 miles; it is brought by sea from Kent, and a wagonload costs at the quay 10s. The method employed is this: The teams of five horses and a wagon and two men go out about 12 at night, load at Malden, return, unload, bait, go again with the same wagon and horses and return and unload and all over by 1 o'clock at noon. This is, I think, the severest work I ever heard of; 24 miles with so heavy a load, twice to be loaded and twice unloaded by the same men, yet it is here common; they reckon that every load costs in the whole 20s. They lay from five to eight on an acre, either upon a clover lay while feeding, or on a summer fallow; the effect exceeds anything I have met with; a very thin dressing of it is seen immediately to an inch, like rotten dung, and lasts twenty years; fifteen in great heart. Mr. Cott showed me from his garden a field of wheat hanging on the side of a hill at the distance of half a mile, one part of which was evidently much inferior to the rest which was in general laid; that part was the only spot not chalked, the farmer not having time to finish the field; he was present and confirmed the account. The same farmer (Mr. Parkinson, of Brackstead) having chalked a field, brought some in a cart as they returned from the field, and spread it thinly on one spot in a piece of poor, dry land; the whole was sown with turnips; during the whole season from their coming up that spot was to be seen at a great distance, and the roots were far larger than anywhere else.

They think their lands will do nothing without chalk, insomuch that the whole country will, in a few years, have all been chalked. The soil on which it does such wonders is loam; they have very little clay and no sand. On gravels the effect is but slight; it is the good sound loam in which it answers like the richest dung.

It is a general opinion among them that land which has once been chalked will not take it again, and this opinion seems to prevent the trial; they acknowledge, however, that mixed with earth and dung it is even then excellent. A very particular circumstance they have observed is that laying a slight dressing of chalk and earth or dung on a field never chalked will take so much effect that the same field will not then answer to chalk completely. Another remark they have also made is that the chalk presently gives the land a red color; so that a part of a fallow that has been chalked will, from the tinge, be discernible at a distance.

Upon my asking Mr. Parkinson if they ever laid chalk upon meadows, he replied they did not require it, besides, they supposed it would do harm as they observe that it is a strong enemy to grazing; that is, to the ground covering itself with good grass. A field which before chalking will run of itself to a fine head of white clover no longer does it after chalking; this is very remarkable, for one would suppose what is manure for corn would be so to grass.

The chalk is not soft, but rather hard; the sharpest frosts leave very many lumps unbroken, so that they break them with pickaxes; and the hard bits that break to a clear white they say come from the bottom of the pit and are esteemed better than the pieces which crumble between the fingers. I tried some pieces at Mr. Cott's in vinegar and water; the effervescence with the former is pretty considerable, though not near equal to what I have seen; but in water it falls very slowly, if at all.

Some farmers have tried lime, and with great success, upon the soils proper for chalk; this is a fresh instance that the excellence of these manures much depends on the soil whereon they are laid; on good loams they take full effect, but on poor lands they find nothing to work on. About Ensield the same chalk does wonders, which at North Mims has very little effect; the one is a rich loam, the other a poor gravel.

An interesting account of air as a plant food is found in the Annals of Agriculture and Other Useful Arts, published by Arthur Young, London, 1786, volume 1. In this volume, on page 169 and following, is an account of some attempts to apply air as a manure to the soil:

The theory which our great philosopher started, that phlogiston is the food of plants, appeared to me so important in the philosophy of agriculture that it engaged my earnest attention. It has never been my conduct to abandon to speculation that which can be brought to the test of experiment. But a person in such retirement as I live in, without opportunity of communicating with practical chemists and philosophers, with smaller means of overcoming difficulties by force of large expenses, and without experience in the sciences necessary to pursue such inquiries, far from all other assistance; a person thus situated may feel very earnest desires to pursue a line of activity and vigor, and yet experience the mortifying conviction that, for want of better support, his wishes may be in vain and his efforts useless. Many of these feelings have been mine through this little beginning of my inquiries; imagining a multiplicity of experiments which I had not the power to execute.

Being desirous of knowing what were the discoveries on which this theory was founded, I read the five volumes of Doctor Priestley with attention, and also Doctor Ingenhouz's experiments on vegetation; and I was exceedingly surprised to find that, amidst a great career of experiments that may indeed be called a new world for the ingenuity of mankind to range in, though the trials were numerous and decisive which prove the power of plants to imbibe phlogiston from impure atmospheric air, yet those which show it to be taken in as a pabulum or food are very rare. Even in the most remarkable of Doctor Priestley's, the willow plant thriving best in inflammable air, an instance is given in the same page of mint thriving much worse in it than in common air. And in a letter which I had the honor of receiving from him upon this subject, July 1, 1782, he expresses himself thus: "Though I have no doubt but that phlogiston is the essence, as we may say, of the food both of plants and animals, they are not capable of extracting it except from certain substances and in certain circumstances; and phlogiston administered in any other way infallibly kills both." The doctor means, I apprehend from other expressions in his correspondence, that the phlogiston must be given either as the result of putrefaction applied to the roots, or else in air applied to the leaves, in which I entirely agree with him. The labors of that truly great man are almost universal; a reach of sagacity, a depth of penetration, united with an ardor, and even enthusiasm, in pushing his researches with an unremitting industry that removes difficulties in the very moment of discovering them, would have left us nothing to wish in the present inquiry had it been possible for one mind to bring to maturity the ideas he has thrown out for the employment of thousands. The variety of his pursuits has prevented so marked an application of his discoveries to my favorite art as might otherwise have happily advanced it.

If there are any experiments extant in which the express application of phlogiston, or of inflammable air, to the roots of plants as a manure has been made I am ignorant of them. No such application, or even conjecture of the result, appears in any work that I have consulted; and yet it seemed to be the only method by which the question of that substance being the food of plants could possibly be decided. The effect of it on leaves, from the experiment of Doctor Igenhouz, seems rather to be an edulcoration of impure air for the purpose of making it salutary to the human body than necessarily beneficial to the growth of the plant. If this is not the exact result, I may at least observe that the doubt which arises might be very easily resolved by those who have the skill and apparatus necessary for such experiments.

The leaves of a plant may perform the office of lungs in the body of an animal, and inflammable air may be as salutary to their inhalation as dephlogisticated air is in the respiration of animals; but it no more follows (however likely it may otherwise be) that phlogiston is therefore their food than that pure air is the food of man.

Following this are records of a number of experiments, and the conclusions are given on page 184 and following:

Many of the preceding experiments may, perhaps, be found to open the way toward a more consistent theory of vegetation than has yet been established. Had not inflammable air been tried the leading feature for selection would have been the effect of the volatile alkali, which is uniformly excellent and, as putrefaction is known in common practice to yield admirable manure, it might have been concluded, with great propriety, that the volatile alkali was the food of plants, a theory for several years the favorite deduction of my practice. But inflammable air having so decisive an effect, analyses, if I may use the expression, of that alkali show us to which of its parts we are to attribute the result, viz, phlogiston in a volatile state.

The volatility of the element seems essential to its action on vegetation for, in a fixed state, it appears to be attended with little or no effect, and in most cases with a mischievous one; for, though charcoal operates considerably as a manure, yet the white ashes of that body being almost uniformly superior to it will not permit us to attribute the effect to its phlogiston. We are rather to suppose that it operates mechanically in the manner of wood ashes. Pitch, tallow, red lead, sugar, and powdered flint are poisons; these substances abound greatly with phlogiston, but not in a volatile state. It is very remarkable that in the form of a liquid it is mischievous unless in the volatile alkali; not only in spirits of wine, but in that most volatile liquid of all others, ether. Oil of every kind the same, and in general let it be mixed with what it may; a circumstance the more remarkable, as a very ingenuous physician (Doctor Hunter, of New York), for whom no one has a greater respect than myself, actually fixed an oil rendered miscible with water as the food of plants. Keep that mixture, or any other substance in nature capable of putrefaction, till it is putrescent, and I have no doubt but you have the food of plants. Why? Because you then have phlogiston in a volatile state.

Still, however, spirit of wine being so prejudicial, surprised me a good deal till I found it was generally considered as composed of an acid united with phlogiston. All the three mineral acids are uniformly poisonous to vegetation; the acid is, therefore, prevalent enough in the spirit of wine to act in its usual manner. Sulphur also has always been a poison, though in some instances it has seemed to act for a short time as a stimulus. Fixed air proving in any case beneficial surprised me, for if the food of plants depends on the volatility of phlogiston the result of putrefaction (which is the fact in nineteen instances out of twenty) then every antiseptic ought to be pernicious (not to mention the proof Mr. Bewley gives of its being an acid). We must, however, remember that the benefit of it in the preceding trials is by no means so well ascertained as that of inflammable air.

To discover facts hitherto unknown in science can hardly fail of being useful in the end, however deficient in that respect they may appear at first. The inquiry is worth the pursuit, though not immediately applicable to the practice of any art. But, in the present case, we can scarcely take a step that is not nearly connected with common agriculture. If phlogiston in a volatile state be the food of plants the farmer has a lesson of infinite importance to him; to acquire and cherish as much as possible the effects of putrefaction and consequently to manage his dunghills and other receptacles of manure in such a manner as to prevent the escape of the volatile principle generated by the putrescence. In this view the practice of frequently turning dung over, which is reckoned by some writers so very excellent, will, perhaps, be found after one stirring uniformly pernicious and tending only to let loose and dissipate in the atmosphere the essence which would most contribute to the fertility of the fields. Without a certain degree of putrefaction the phlogiston will not be volatile; continued too long it will all fly off. Consistent with this theory is an observation I make every year in my own farmyard. I have a standing sheepfold, part covered and closed and part of it uncovered; the whole is littered equally, but one load of the dung in the covered part is worth two in the uncovered. When the carts go in to be loaded it stinks much more offensively and makes the men's eyes water that move it. This shows that the volatile alkali and phlogiston are retained and that the action of the sun and atmosphere is to carry them off.

I wish much to have made some progress in deciding the effect of sunshine on soils, but, except the experiments on earth kept seven years excluded from both light and sunshine and also kept in a vault, I have not been able yet to execute the trials I have projected, though some of them are at present in course. Those were decidedly against the soil imbibing any food from the action of that luminary, and the whole range of common husbandry seems to speak the same language. Covering the soil with a thick, smothering crop of clover, tares, pease, etc., is found to enrich it far more than a summer fallow. Old meadow land receives very little of the sun's rays, and some woodlands none, yet these are the richest soils all over the world, because the putrescence of vegetable and animal matter impregnates them with volatile phlogiston. I can not conclude these experiments without admitting an imperfection for want of more spirited and extensive trials (many of which I had planned), but the expenses necessary are beyond my ability, and no day passes without my regretting that insufficiency for pursuing the hints that arise. Time is precious.

> Life flies fast away, and leaves one little more than wishes to execute what fortune forbids. I should be glad to try electricity by means of a machine constantly turning by wind or some other power. I want a very lofty conductor to bring down the electric fluid from the clouds, to impregnate certain recipient bodies, with and without plants growing in them. I wish—but wishes are vain and unworthy every philosopher; experiment is his business; we must content ourselves with doing the little in our power.

The question of lime was again considered in a communication read by John Lang to the Philadelphia Society for Promoting Agriculture, on August 9, 1808, and published in the second volume of the Memoirs, page 1 and following:

> We have for some time past heard much talk about two varieties of lime, the one useful or favorable to the growth of vegetables, when used as a manure; the other hurtful or pernicious, and therefore not to be used for that purpose; the first is termed calcareous, the other magnesian lime.
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> The first notice we have of this magnesian lime is from a communication of Mr. Tennant, published in the London Philosophical Transactions.
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> This is doubtless a subject of great importance to farmers and, in my opinion, deserves to be more fully investigated. If all lime which contains magnesia is only useless as a manure, it must be of great importance to our farmers to be informed how they may be able to distinguish this from the calcareous lime; but much more so if it is, as Mr. Tennant says, destructive to vegetation, and that it diminishes the fertility of the soil. The distinguishing characteristics of these two varieties of lime mentioned by Mr. Tennant, it would seem, can only be discovered either by analyzing (which process farmers are generally ignorant of) or by making experiments by applying it to the soil. It is said that magnesian lime when used in too great quantities renders the soil less fertile, and wherever a heap of it has been left on one spot vegetation will be prevented for many years; while of the other sort of lime, a large quantity is never to be found injurious, and that the spots which are entirely covered with it become remarkably fertile instead of being rendered barren.
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> From the above statement it would appear that by far the greatest proportion of all the limes used either in this country or in Europe are of the magnesian kind, or in other words must contain a certain proportion of magnesia. For my own part, I have never seen pure calcareous lime, unless that made from calcined shells may be denominated such; though I must own I am not chemist enough to be able to discover the magnesian lime, except by its effects upon the soil, as above described by Mr. Tennant and Doctor Darwin. The distinctions which some farmers make of hot and mild lime, Mr. Tennant believes to mean magnesian and calcareous lime. And the Doctor says he is informed that the magnesian lime is preferred in architecture, and is said to go further in making mortar, etc. If this is the case I think it will be admitted that all the lime used in the United States, either for building or manure, is of the hot or magnesian kind; as it is well known that the lime of this country is generally stronger and of course will go further in making mortar, or as a manure for land than English lime. Were our farmers in this country to discover lime of so mild a quality that thistles and grass would grow up through the sides of the heaps of it, but at the same time it would require three loads of this lime to produce the same effects upon their land as two loads of the lime now in use, I think they would surely prefer the latter to the former. Our farmers know very well that wherever they lay their lime heaps every particle of grass or other vegetables will be destroyed; and that the spots on which it lay will not bear any crop for a year or two after, unless they are careful to remove it so clean that no more shall remain on these spots than the same proportion which they spread over the rest of the field. They likewise know that if they should leave their lime heaps exposed to the influence of the atmosphere, to successive frosts and thaws, rains and snows, etc., it would in time become as mild as the calcareous lime destroyed by Mr. Tennant. But then it would be useless for mortar, and for land it would be like some medicines of which the chief recommendation is that if they do no good they will at least do no harm; and for that reason they commonly cover the heaps over with sods, or straw, etc., till the land is prepared for putting it on. Our farmers likewise know that poor land will not bear so much lime as rich land, and that if they should by mistake over-lime their land, the succeeding crops will rather be hurt than benefited by it; and in such cases there is no remedy but either to

give the field a dressing with dung or let it lay a year or two till the heat of the lime is partly given out, and then it will have its effect. From this I conclude that lime must act as a stimulant, and that the quantity applied to the land ought to bear an exact proportion to the carbonic, or vegetable matters contained in the soil. It is well known that stimulants used in small quantities are in some cases very useful in the animal economy, but in great quantities they will destroy animal life.

I would not by any means presume to call in question the results of Mr. Tennant's or Doctor Black's experiments; on the contrary, I am rather inclined to believe that all stone lime contains a greater or lesser proportion of magnesia; but that the lime which contains the greatest proportion of that earth is totally unfit to be used on land as a manure, I think deserves a second consideration.

Doctor Darwin observes that the substance called chalkstone is almost wholly magnesia; now I know from experience that chalkstone land is the most kindly to all sorts of grain of any soil I am acquainted with, and will bear a longer succession of severe cropping before it is exhausted. But perhaps it is the process of calcination which gives to the magnesia that caustic quality which renders it so hurtful to vegetation, as Mr. Tennant found by his experiments, that 30 or 40 grains of lime did not retard the growth of seeds, more than 3 or 4 of calcined magnesia. From which Doctor Darwin concludes that, as both injure vegetation in large quantities, they may both assist vegetation in small ones.

Consistent with the doctor's remark I would just observe that there are many substances which make rich manures when used in small quantities; for instance, I have seen very great crops of barley got by sowing the land with pigeon's dung, as thin as we sow rye, and harrowing it in along with the seed barley; whereas had it been put upon the land as thick, or half as thick, as we would put stable or barnyard dung, it would as effectually destroy all vegetation as hot lime used to excess. The same remarks will apply to the dung of all kinds of domestic fowls, also to human dung and urine, so much valued in China. Common salt has often been recommended as a great assistant to the growth of vegetables when used in small quantities, whereas it is well known that the excessive use of it will render land totally barren.

It will be admitted on all hands that all animal and vegetable matters contained in the soil must undergo a decomposition by some means or other, so that being thereby reduced to such a state as to be easily soluble in water, they may be readily absorbed by the tender roots, by some termed the mouths of plants. That the roots of plants naturally possess to a considerable degree the power of producing this decomposition, I have had occasion more than once to observe, in the case of planting potatoes with woolen rags instead of dung. I have seen fine crops of potatoes raised by dropping a small piece of woolen rag, not larger than the hand, in the furrow along with every set of the potatoes when planted, and I have observed when the potatoes were gathered in the fall that, in every instance where a potato plant had failed to vegetate, the rag was turned up entire, very little damaged by being buried under ground; whereas, on the other hand, not the smallest vestige of the rags were to be seen in any part of the ground where the plants had succeeded and grown to perfection. Only I observed in some instances where the rag had been uncommonly large, a white moldiness upon the soil about the roots of such plants, which seemed to me an indication that more nutritious matter had been formed than could be absorbed by the roots. Besides I observed the palms or tops of such plants were always large and of luxurious growth, while the potatoes at the root were small and not fully ripe.

But there are other animal and vegetable substances which require more powerful solvents to prepare them for the food of plants; such substances must be decomposed either by means of the putrid fermentation, or by the application of hot lime, etc. But while the putrid fermentation is going on, it is exceedingly noxious to vegetation, as we may see by the bad effects of putrid or stagnant water upon the roots of tender plants; while on the other hand, hot lime will check the progress of putrefaction, and at the same time very quickly effect the decomposition of various bodies; thereby preparing sweet and wholesome juices, whether they consist of carbon, phosphorus, oils, or alkali, or compounds of all or either of these. And I conceive if the lime meet with a sufficient quantity of such substances as it in this manner acts upon, it will, by mixing with such juices, thus prepared, be thereby deprived of its caustic quality in the same or somewhat similar manner to that whereby magnesia or chalk blunts, or sheaths, the points of the sharp particles of acids. But if the lime does not meet with a sufficient quantity of carbonic or other matters in the soil to act upon, so that its caustic quality may be completely overcome, then in such case it will act upon the tender roots of the growing plants, in the same manner as it acts upon grass or other vegetables when laid in heaps on the surface. And this is in my opinion the cause why lime in some instances is hurtful, instead of being beneficial to land.

Upon the whole, I think instead of troubling our farmers about distinguishing the different qualities of magnesian and calcareous lime, it will be better to advise them to use lime sparingly on poor land, and at the same time to use every exertion to increase their dung and compost heaps, whereby their land will be prepared for the application of lime, not only with safety, but great advantage.

An interesting article on the improvement of soils is found on page 187 of the Memoirs of the Philadelphia Society for Promoting Agriculture, volume 2. The communication bears date of March 9, 1810:

It is generally acknowledged that the best land may be reduced to sterility from an injudicious rotation of crops. It remains in a great measure to be proved, whether a farm, which from bad management had been rendered barren, can be restored to its pristine fertility, by a treatment, not beyond the reach of every farmer (nor without the farm) who possesses the land, free from incumbrances, which are nearly equal to the supposed value of his worn-out farm.

When an inquirer examines the publications of those who have given the results of their experiments, it appears not only practicable, but easy; frequently, however, some circumstance is not mentioned in the communication or something not attended to by the reader who intends to make the same successful experiments, but fails, from the causes stated.

The Rockland farm exhibited a subject for experiment, as it had not only been reduced by cropping, but generally, became a common for every animal to take what remained of the scanty natural, but coarse, herbage; having read in various books the results of sowing plaister and clover, it was presumed that sowing plaister and clover would be the extent of the expenses required to fertilize the fields in a few years; a few experiments proved that the plaister and clover seed were both lost, as no one could at any season of the year point out what field or upon what part of any field they had been deposited, unless where the briars and bushes had been eradicated.

It should, however, have been mentioned that the soil was generally a cold or heavy clay, some blue, white, light brown, and a few spots of red clay, loaded with hard blue stone and rocks, chiefly quartz, mixed with iron and copper. Some of the experiments were made with plaister, others were made by top dressing with lime, at the rate of 25 to 30 bushels per acre; the lime was brought 20 or 25 miles from the kiln, and laid on the field at 25 cents per bushel; it was formed into a bed of about half a foot thick and covered with earth, plowed and thrown over it, before it was slacked, that all the phosphoric principle disengaged by the water might be united with the earth which covered it; a heavy harrow was afterwards passed over it, so soon as the shell was reduced to powder; the bed of lime and earth was then frequently turned by the plow and harrow until the whole assumed the appearance and smell of soapers' ashes, containing about 10 parts of common soil to 1 of lime. It was then carted and spread regularly over the field, and in every instance it gave a return of clover equal to 10 loads of stable manure to the acre. The idea of mixing the lime and earth was suggested from spreading the refuse mortar of lime and sand gathered from about buildings and laid upon the field, the effect of which I observed was more immediate than any equal quantity of lime; though mixtures of lime and earth were equally so, in both cases the lime was completely pulverized, and the sand and earth broke up the communication of lime with lime, and the succeeding rains carried the fertilizing principle of the lime, as from a sieve, into the soil where it was spread; it completely divided the soil, rendering that open and warm, which before was compact and too cold for the roots of the grain to live in.

The whole soil, which before felt dead under foot, became so elastic that persons of observation, by walking over the field in the night, distinctly told how far the lime and earth compost extended. The color of the soil was likewise changed into that of chocolate.

These effects presented several ideas which had not occurred to me before, viz: That anything which would separate the particles of the soil and admit the air would render these cold and heavy clays warm and fertile; that the free intercourse of air would carry off the acid. To meet this, plowing in the fall was adopted and found successful. One-half of a field six years ago was plowed in the winter, the other half plowed in the spring. That part which was plowed in the spring has never brought grain or grass equal to the other. It should have been observed that the field had not been plowed for upward of twenty years, and of course a great body of rubbish and roots were plowed in after the briar hook and grubbing hoe had smoothed the surface. Spreading of manure in the autumn from the compost bed has also been introduced with universal success, both upon grain and grass fields, the lye or salts of the manure being carried into the soil by the rains upon the breaking up of the frosts, which have in some measure prepared the soil to receive it. High agricultural authorities, even bottomed on accurate observation, are opposed to the practice of spreading out manure in autumn. Amongst these we find the justly celebrated Lord Kaims, in his Gentleman Farmer, a work upon first principles, and deservedly of the highest authority. A departure from his judgment is only to be allowed where facts would censure silence; nor should his name have been mentioned unless to avoid the charge of writing without attending to what has been said on that subject. It is no conclusive objection that "the strength of the manures will be carried off by winter rains or exhausted by the frost." Are not the warm showers more so, and are not the exhalations more copious in a warm than in a cold temperature? Is the descending of the sap in trees no monitor as to the season for spreading out manures, and about the operation of nature for renewing and invigorating the process of vegetation?

Briar bushes and all vegetable substances have been covered up with earth, rotted, and used with the same success as stable manure, and so far and so long as they separate parts of the soil and admit the air they fertilize and change the color of the mold. These experiments, tested by frequent repetition, have laid a foundation for experiments less expensive and equally fertilizing for the production of grass and grain. Plowing and sowing for the purpose of producing pasture and accumulation of vegetable soil have been adopted. For this purpose wheat, rye, Indian corn (maize), buckwheat, and oats have been sown upon fields plowed, which were incapable of producing any crop. None of those grains have produced pasture and vegetable soil equally valuable to that from the oats. Where the others have failed its roots have pierced, disarmed, and vanquished the inhospitable soil and rendered it fertile. The winter plowing is continued and the oats are thrown in as early as the season will allow, sometimes even in February, either upon what has been plowed in autumn or in the fields which were in corn the preceding year or in pasture oats the preceding fall. In general they afford early pasture, and when they are replowed in July and August and sown again with oats they furnish excellent pasture from early in September until late in December, during that season when all other pasture is generally dried up. The first sowing of oats only gives about two months' pasture, but the roots and remaining herbage afford a manure for the second sowing, and this always yields four months' valuable pasture, which no other course known to me will afford. In September, October, November, and December considerable attention is required to preserve the young clover which the field will be able to raise in the second year of the oat pasture. If sown with the oats in the spring, the cattle should never be put in while the ground is too moist, as they would destroy and tread it into the soil; and sometimes dry seasons are also highly injurious to the clover. When the clover is sown with the second sowing of oats the same care is required to prevent its being trodden in by the live stock. For this purpose it is always necessary to have a spare field of old pasture, which they will feed upon in wet weather and which they would not relish in dry weather. To guard against a dry season it is most proper never to pasture the oats where the clover is sown so much as to prevent the herbage of the oats from giving shade to the clover. So soon as a field will produce clover luxuriantly, there is no farmer at a loss how to make his field as rich as he pleases, and having got them into good heart, it will be to his interest to put them in such rotation as shall increase the vegetable soil and consequent fertility of his fields.

It is almost unnecessary to mention what will make its way to the understanding of every farmer, viz, the many advantages gained from treating his barren field in this way.

1. Early and late sweet pasture from such fields which otherwise produced a scanty, coarse herbage unpalatable to every animal.

2. Immediate reward for his labor; the stock are supported by it within two months from the time seed is sown; the two returns give six months' green food; he is not, however, to depend upon it for all his summer pasture.

3. Perhaps it is one of the most effectual means to root out garlic, because what have escaped the plow in the spring are eaten down with the pasture from the first sowing of oats and prevented from going into seed; the plowing in July and August expose so many of its bulbs to the sun that few shoots are to be found in oats sown for fall pasture.

4. It is an easy and profitable way of clearing grain fields from every species of injurious weeds, as it will convert them into vegetable soil and enable the farmer to raise whatever grain or grass he shall judge most suitable to the soil.

5. It will save the expense of a fruitless summer fallow, and the green herbage will aid the dairy.

6. It enriches the farm from within itself, and no expense is required beyond the reach of any farmer; by rising one hour earlier, and working one hour later than usual, for two weeks, he may plow and sow 2 acres, as an experiment. The pasture will recompense his labor, while his soil is greatly improved; it is equally evident that the fertility of the soil is acquired partly from the roots of the oats opening the soil and introducing the air and warmth of the sun and partly from accession of vegetable soil produced from the decomposed roots of such pasturage; but even before the roots are converted into soil they produce the most beneficial effects. Those from the spring sowing retain the moisture and supply the summer sowing with it. The roots from the fall pasturage, being full of sap, introduce winter frosts everywhere into the soil, which, swelling with the congealation, separates the particles; for it is to be observed that roots, while the stem is eaten down by the stalk, do not become hard, but are more numerous than when the plant is matured into grain. It is however necessary to sow at least double the quantity of seed to that required for crops of grain, the pasture being so much the thicker and the increase of vegetable soil from the decayed roots so much the greater.

It is not to be expected that one or two repetitions of the series of oat pasture will make the soil equally rich as a common dressing of stable manure, which from a farm of 100 acres will not in general extend over more than 10 or 15 acres; this gives to one acre nearly the vegetable soil produced from 7 or 10 acres. It is to be remembered that the object proposed was to render worn-out or barren fields productive; and in no case have I found a field which was not after two years, oat pasture capable of producing clover and receiving the gypsum with evident advantage. So soon as a field produces clover no one is at a loss how to produce advantageous crops afterwards. It is in every one's power to estimate what the plowing and seeding per acre of oat pasture with cost, and, according to circumstances, so will the expenses be, but in general where the expenses are high, the value of the pasture is equally so, and if even granted that the cost of plowing and seeding shall be double in value to the pasture produced let the comparative value of the field be fairly estimated before the course was begun—a waste or worn-out field—and what it is now, when the course is completed and laid down in clover, timothy, or orchard grass.

It will be of the first importance to have at least two fields, otherwise if the cattle are constantly upon the same field it will not be found so productive, and in wet weather they should be turned into some field where the herbage was too hard in dry weather. It will be eaten greedily by the cattle after they have been satiated with the soft blades of the oats; under this management, beeves have been fatted for family use and taken off in December without any grain. It is observed that the oats scour at first, but the free use of salt readily corrects the complaint, and in no pasture do they rise faster in flesh, and the juices of their meat are uncommonly grateful.

The fields which have been in corn the preceding year have also been sown in the spring without being replowed, and have done equally well, except upon heavy clays, when the spring has commenced with heavy rains which have rendered the soil too compact to be opened, even with a heavy brake harrow, drawn by four-horses. The fields from the oat pasture the foregoing autumn have also been sown without replowing, when the spring has set in without much rain, after severe frost; not only the oat pasture but also the clover sown therewith have answered well.

Oats have also been sown among the hills and drills of corn after it has received the last dressing. It has succeeded, without any visible injury to the corn, provided care has been taken not to injure the roots by the plow or harrow at the time the oats were sown.

It has been inquired, Are not all crops of oats exhausting? If so, how can two sowings of oats in the same year render the soil fertile? It is granted if oats shall be matured into seed they will certainly exhaust, but if cut off while in the blade they and all culmiferous plants will fertilize. The experiment was made with Indian corn, sown broadcast, cut twice, and carried to the stable, and a crop of turnips taken off the ground the same season; the manure was laid on before the corn was sown, but none was given when the turnip seed was put in.

Another way in which oats fertilize appears to be from increase of vegetable soil. This is within the view of every observer. The remains of the pasture plowed in, particularly in July and August, is speedily decomposed, its tenderness and moisture aiding the dissolution. But dry stubble and husky roots are difficultly decomposed, nor do they produce so much carbonic or coally matter in the soil, which chemists say decomposes the water and produces the air required to promote vegetation. As the vegetable is produced from air and water, and not from earth, which seems to be no more than the laboratory where the process of vegetation commences, and finally serves as a matrix to hold one part of the plant while the other parts are raised aloft in quest of superior aid to complete the inscrutable operations of the vegetable fabric.

It has also been inquired, Will this process of oat pasture fertilize everywhere? It is answered that where the soil and climate are the same the effects will be the same also. A description has been given of the soils where the experiments were made and are still going on. If experiments of the same nature shall be made upon a different soil and climate the result will be different, and more or less favorable, according to circumstances, and for which the practice now mentioned can not in justice be rendered accountable. If my shoe fits my foot I am warranted to say it will suit a foot of the same size and shape everywhere; let no one conclude that it will fit a foot of larger or less size or different form; but I must confess that passing over things equally obvious I have run into numerous and expensive errors.

But when it is inquired upon what evidence it is to be received, the reply is at hand; living evidences are at the command of everyone who chooses to make the trial; let him, however, be on his guard against suffering himself to take a crop in place of the spring pasture oats.

If it shall still be inquired, How does the oat pasture fertilize? it may be also observed that the constant verdure and green herbage prevent the rays of the sun from parching the soil and depriving it of its moisture and air, both of which are highly necessary to vegetation. The double portion of juicy vegetable matter arising from the two crops of pasture in the same summer being everywhere united with the common soil, partly mechanically and partly chemically, renders the soil capable of retaining sufficient moisture and elastic air to make it open and warm, and by which the soil does not only become thicker by going downward, but actually expands or rises so as to give a furrow, considerably deeper than formerly, over immovable rocks. Some years ago a field in view of the farmhouse marked the broad rocks during the course of every crop; they are now covered with so much soil that they are seldom observed. The two plowings also contribute to the increase of the air in the soil, without which no soil can be fruitful, there being no vegetation in vacuo. Tull's horse-hoeing husbandry was introduced under the idea that the pabulum of plants was pulverized earth. The fact daily before us is that pulverized earth retains the moisture and air as the handmaids of vegetation. Some experiments have lately been made the results of which favor these remarks, viz, "that soils afforded quantities of air by distillation somewhat correspond to the ratios of their values."

An article on the best method of reclaiming worn-out land was contributed by John Lang to the same society on December 12, 1810, and published in the second volume of the Memoirs, page 299, and following:

I conceive it a duty I owe the society to communicate through you the result of some experiments which I had set about for the purpose of ascertaining the best means of reclaiming old worn-out land. I had fondly listened to the method proposed by some, of improving with clover and plaster, without the use of lime, and determined to try it. The field which I pitched upon for my experiments contains about 14 acres; it had been cleared about fifty-three or fifty-four years ago and continued in constant cultivation for upward of thirty years without manure of any kind. Some old people now living say that they have seen as good crops of wheat cut from it as ever they saw; but it was kept in cultivation till the produce would no longer pay for the labor, and has been thrown out a common for more than twenty years, till I fenced it in. I had the whole of the field plowed early in the spring of 1808. In the month of May one part of it was plowed again, and sown with buckwheat; this buckwheat was plowed in when in blossom and the land sown with buckwheat a second time, which was likewise plowed in and sowed with rye.

The other part of the field was limed at the rate of 25 bushels to the acre and planted with corn. The lime which I used was of the hot kind, from a quarry which is generally approved of for land in those parts; makes very strong mortar for building, but is not used for plastering, being granulated and not very white. I suppose it to be similar to that described by Doctor Darwin, which he supposes to have been primitive lime, broken down by the action of water and petrified a second time, which he thinks is the strongest lime.

The following summer was very dry, which, together with the heat of the lime, I supposed to be the cause why the corn became stunted and produced almost nothing. In the spring of 1809 the land was plowed and sowed with oats and clover; the other part of the field which was now in rye was likewise sowed with clover at the same time, and as soon as the clover began to appear above ground the whole field was sowed with plaster.

At harvest the oats was a very good crop, the rye was tall and well eared, but rather thin; perhaps it was owing to this circumstance that the clover among the rye looked better and more plentiful than that among the oats. I had not seen it until Wednesday the 4th instant, when I found that part of the field which had been limed closely covered with fine clover, whereas on that part which was not limed almost the whole of it had perished last winter, and what plants remained were weak and sickly, and abundance of wood grass beginning to appear, with which the field used to be almost covered while it lay a common; whereas not one plant of it is to be seen on that part which was limed. From this I concluded that if the system of improving with clover and plaster without lime should succeed in the end, it must be by a number of repetitions of the same process, which would require time and labor equal to if not exceeding the expense of lime, and the result uncertain. I therefore ordered that the part of the field which had not been previously limed should be limed as soon as possible, twice plowed, and sown with rye and clover next spring.

It was the opinion of the man who farms for me, as well as of others who made observations, that I missed it by planting corn with the lime; that if I had sown oats and clover the first spring, I would have had a profitable crop, besides gaining a year by my improvement, which was lost by the failure of the corn crop and part of the strength of the lime exhausted to no purpose. I am fully aware of the objection which some have to oats as an exhausting crop, and therefore ill calculated for advancing the improvement of worn-out lands. At the same time that I disapprove of the absurd practice of some farmers of sowing oats and buckwheat, year after year, as the worst of all rotations, I am convinced from long experience that an occasional crop of oats is no more exhausting than wheat, rye, or corn; that it is an excellent nurse for clover, a profitable crop for the farmer, and the straw good fodder or litter, without which he can not get much dung, the value of which is not sufficiently appreciated by many of our farmers. Every kind of grain which ripens its seed is an exhauster; even clover, which is the most ameliorating crop which we know, if it is but a moderate crop and left standing until its seed is full ripe, instead of improving, will be found to exhaust the land.

Before I conclude I must take some notice of the mild lime which I mentioned in a note at the bottom of page 8. I then supposed the mild lime above mentioned to be the property of Mr. Barnitt, of Marlborough Township, but when I was with my friend, Mr. John Mills, on the 4th instant, he told me that Mr. Barnitt's lime is the hottest and strongest lime in that neighborhood, that the lime which I alluded to is the property of Mr. Baker, of Newlin Township. The two limes are not more than 2 or at most 3 miles apart; Mr. Mills's farm lays nearly in the center between the two, and he occasionally uses both. He says that it requires 130 bushels of the mild lime to go as far on land as 100 bushels of the hot lime, that the mild lime is in its effects on land somewhat similar to that of dung, as it gives out its strengh to the first crop, but in one or two crops more it is all gone; whereas, though the hot lime sometimes instead of helping rather injures the first crop, its good effects continue for many years. He showed me a clover field, one part of which had been manured with Mr. Barnitt's hot lime and the other with Mr. Baker's mild lime. I observed that wherever a heap of the hot lime had lain not a blade of vegetation of any kind had appeared, though Mr. Mills told me that every particle of it was shoveled off as clean as possible; but on that part of the field where the mild lime was put no such effects were produced. He told me further that the grain was best on that part where the mild lime was put, but the clover is greatly superior on the other part (it was all plastered alike), and I have no doubt that the succeeding crops will evince a decided preference in favor of the hot lime. I expect to procure specimens of both the above limes for the purpose of having them analyzed.

A very extensive examination of the use of gypsum as a fertilizer is also found in this volume. The article was prepared in 1797 and dedicated to George Washington, President of the United States, in the following language (page IX):

SIR: The following collection on the subject of the agricultural properties and uses of the gypsum, having been undertaken by me at your desire, I have thought there was a propriety in presenting it to you. However unimportant other parts may be, those which contain practical results I flatter myself will be useful.

I have had frequent occasions of knowing that the encouragement of agricultural improvement and information is among the favorite wishes of your heart. It is on this account and not with a design to give it an undue importance by placing it under your notice that I have been induced to inscribe to you this publication.

It is peculiarly consolatory when we can draw any portion of our comfort from our misfortunes. Your retirement from public life will afford you leisure and opportunities, by your patronage and example, to promote the interests of agriculture. Some compensation will thereby be afforded us for the loss we shall sustain by your resigning the helm at which you have so long, so wisely, and so safely steered our political barque.

Long may uninterrupted health, that first of blessings, enable you to enjoy the splendid evening of a life so much devoted to your country as to have been but little dedicated to yourself. And that you may be as happy as you have been eminently instrumental in making millions of your fellow-citizens is my sincere and ardent prayer.

I have the honor to be, with the most true and respectful esteem,
Your obedient servant,
RICHARD PETERS.

JANUARY 3, 1797.

In the preface to this article is a strong argument for the establishment of a department of agriculture, page IX:

And yet the greatest improvements in husbandry have been either suggested or made by those who were not professional farmers. If pecuniary assistance should be required out of the public funds it should be afforded. A cent expended, with propriety, to aid and reward genius and industry in pursuing agricultural experiments and researches will add an eagle to the public stock. This is applying nourishment to the root of the public prosperity.

Were it without example it would be surprising that legislatures, consisting for the most part of farmers, have done so little for the encouragement of a profession which is calculated, above all others, to produce additions to the common mass of property by creating countless supplies drawn from the earth.

In England the establishment of a board of agriculture under the patronage and pecuniary encouragement of the legislature is recent, but its advantages are incalculable.

In France agriculture is accounted, as it really is in all countries, the basis of public and private wealth and prosperity. Its patronage and encouragement are placed among the first objects of public attention, and radically interwoven with the principles and system of their national policy and government. Perhaps the period is not distant when the public mind here will be turned to this subject. Nothing will then be wanting toward the accomplishment of every-

> thing wished for by the friends to this important and invaluable art. They have received the highest gratification, and must conceive the strongest hopes by observing this subject recommended to the attention of Congress by the President, who has constantly mingled with his other patriotic solicitudes an unabating desire to forward agricultural inquiry and improvement.

On page XV he says further:

> I indulge a hope that men of chemical and philosophical knowledge will be induced further to examine and analyze this powerful substance, with a view more accurately to discover its agricultural properties and the causes of its operation on plants. The farmer, when taught by their discoveries and experiments, will be enabled to render this manure still more valuable by the most judicious modes of application. It will then be felt by the cultivators of our soil that science essentially promotes their interests and happiness. A practical conviction of the advantages derived from it will urge them to afford to literary establishments and men of useful learning the public and individual support they so justly merit.

The question of what is plant food was debated more than a hundred years ago, since it is said on page 93 of this article:

> Nothing has evidenced a greater diversity of opinion among the most eminent men than the question "What is the food of plants?" Nor do they agree about the nature of the air contained in vegetables. Some assert it is mere atmospheric air changed, or liable so to be, into fixed, by ebullition—phlogistic, by fermentation—or dephlogisticated by the sun, the light whereof operates a change in this air not produced in plants in the shade. Of what nature or species is the air contained in plaster; or whether this substance operates by its powers of attracting or retaining moisture, and decomposing, preparing, and communicating to plants the air the fittest for their nourishment, must be decided by others than practical farmers, to whom profitable effects are more important than the most learned and ingenious theories.

In an address by Doctor Mease before the Philadelphia Society for Promoting Agriculture, January 14, 1817, it is stated, on page XVI of volume 4 of the Memoirs of this Society:

> I state with pleasure that I have received information from a correspondent in Maryland of the discovery of large beds of alluvial deposits in Kent and Queen Anne counties similar to some of those found in various parts of west New Jersey, the utility of which as a manure in the sandy or light soils of that district you all know has been found, when cautiously used, to be very great; and I have no doubt that future researches in the peninsula, between the Delaware and Chesapeake, and indeed in every part of the tract constituting the ancient seacoast of our country, will discover similar deposits. The fertilizing properties of those substances can not fail of proving highly beneficial to the land in their vicinity; but I must caution those within whose reach they are not to depend entirely upon them for restoring the exhausted state of the soil; for, although independently of the good effects known to be derived from the mere circumstance of the stimulus given to plants by the new earth in which they grow, considerable advantage will follow the decomposition of seashells and other animal remains with which they are mixed; yet if successive and exhausting crops are taken from land dressed with the new substances; if part of the increased produce be not applied to the feeding of stock in the barnyard, and the manure thus obtained be not used to give body and life to the stimulated soil, their expectations of the treasure now dreamed of from the use of those substances will certainly not be realized. But the addition alone of manure will not answer all the desired end of the husbandman: the earth will sicken even of manure; rotations of green fertilizing or covering crops are indispensably necessary to recover the earth from the exhausting effects of an uninterrupted cultivation of tobacco and grain, or of any one crop. This is not mere theory; the experience of every judicious farmer or cultivator in Pennsylvania will support me in the propriety of this injunction.

A most interesting contribution to the subject of reclaiming the fertility of worn lands is in a paper by Mr. Richard Peters to the Philadelphia Society for Promoting Agriculture, on March 5, 1817.

Among the methods considered, Mr. Peters speaks of the farmyard so constructed as to save all the dung and urine; the value of fall plowing; the use of lime; the proper time of plowing in stable and yard manure; of deep plowing; of change of crops; the use of plaster; the value of orchard grass; explorations for refuse to be used as manures; the collection of summer dung; selection and change of seed on soil; the operation of fire on soils; ditching and draining; the utility of agricultural societies; habits of industry and sobriety, savings banks, and friendly and benefit societies are also discussed. In this paper, on page XXXIII, there is an interesting account of the effects of fire on soils. It reads as follows:

> The effects of fire on soils are well known in foreign countries to be salutary, and here proofs are not deficient. Various modes in which it has been applied are to be found in European books. When carried to excess it is, like all good things abused, no doubt injurious. Nor would anyone wish to destroy the inestimable vegetable matter of a sod capable of being completely decayed so as not to vegetate, for this would be unnecessarily wasting the means of restoring fertility by the cooperation (with this inert vegetable matter) of manures or materials for the food of plants in the earth or in the atmosphere. But where bulbs or other pests are otherwise indestructible, or the substratum be clay proper for burning into highly fertilized manure, there can be no reasonable objection to the application of fire. Denshiring or burnbaking is described in agricultural books, wherein its benefits are developed and the improper use of it pointed out. Burnt clay has been long known to be fertilizing, and so are the ashes of peat and turf. Even burning brush and straw on fields is proved to be almost incredibly fertilizing and productive. Burning the foul cover of wild grass and weeds before plowing for Indian corn, even in the spring, has, in frequent instances, destroyed the grub or the eggs of its parent. In what manner heat operates on soils is not essential, nor is the inquiry whether the effect be produced by the ashes or the mere application of fire. The facts are well ascertained, and that is enough for all practical purposes. Some soils may be less benefited than others, and with some burning may entirely disagree. Whatever may be the theory of or prejudices against this operation, it behooves us at least to try, if even on a small scale, a practice which has the approbation of eminent and successful practical and scientific agriculturists in Europe. And in this, as in every other operation, a farmer should know and calculate on the nature of his own soil, and thereby judge of the expediency and propriety of any practice.

As one means of improving the land the farmer is urged to read literature which will be useful in that direction. On page XLII Mr. Peters says:

> Read and do not slight either foreign or domestic books of reputation for principles and practice on agricultural subjects. Climates may and do differ, but principles are invariably the same. If you have, as you ought, a desire to be well acquainted with your art, gain some knowledge of subjects elucidating its principles, and particularly of chemistry, as connected with agriculture, although you need not aim at being a perfect chemist, nor qualify yourself as a disputant on theories and vain and unprofitable discussions which produce no beneficial results, but, on the contrary, bewilder those to whom information of plain principles and facts and practical lessons are the most necessary.
>
> Home's Principles of Vegetation, Darwin's Phytologia, Hunter's Georgical Essays, Anderson's Essays, Lord Dundonalds' Connexion of Agriculture with Chemistry, Davy's Agricultural Chemistry are among the books, giving a general view of principles, and books of practice you can obtain at pleasure. The former you can use as lawyers read Blackstone's Commentaries, and the latter as they apply to reports for detailed and practical information.

In regard to the prevailing habit of giving distilled spirits to laborers, it is stated on page 50:

> Associations should be formed to moderate, if it can not be totally abolished, the custom of dealing out to laborers ardent spirits—the most dangerous and

> destructive foes to the peace of a community and to the prosperity and happiness of individuals afflicted by a propensity to use them incontinently. Those who furnish the means of destruction are equally culpable with those who perish under their enticements.

An interesting book respecting the fertility of land is that written by Prof. Isaac Phillips Roberts, edited by L. H. Bailey, of Cornell University, entitled "The Fertility of the Land." In this work Professor Roberts takes up the problem of preserving and increasing the fertility of the soil. He defines the term "fertility" as commonly used in a special sense, meaning an abundance of nitrogen, phosphoric acid, and potash, but its true meaning is productive power. He states that land may contain any quantity of plant food in an inert state—that is, in a condition unsusceptible to plants, and yet, be sterile, whereas it may contain only a limited amount of plant food, and if that is available for the use of a plant it will be a fertile soil. He shows by analytical data that even poorer soils have an abundance of plant food, sufficient for several crops if it could all be utilized, while the richer soils in some cases have sufficient for two hundred or three hundred crops of wheat or maize. He says on page 19:

> This vast store of plant food is the farmer's stock in trade, the bank upon which he may draw. Its value can never be accurately determined, since a part of the plant food is not available, and since the power of the plant to secure that which is available depends upon many conditions, such as the correct preparation of the land, the kind of crops raised, the relative amounts of the various required constituents, and the amount of moisture present.

Again on page 32 he says:

> Since the soil and the subsoil contain such stores of potential fertility, and since tap-rooted leguminous plants bring to the surface abundant quantities of nitrogen with some mineral matter, and since many fields receive applications of farm manure from time to time, some far-reaching cause or causes must be present ever tending to seriously restrict production. It will be found that in this country the principal causes of low yields of farm crops are imperfect preparation of the land, poor tillage and hence a lack of available plant food, and insufficient moisture during some portion of the plant's life.

Professor Roberts in his book discusses the best method of tillage, the best means of preserving and applying manures, the best times of applying manures, the usefulness of nitrification, the home mixing of fertilizers, the value of lime, and many other problems connected with the conservation of soil fertility. I close this résumé of the history of soil fertility, its conservation and restoration by citing two classical works by American authors, well known and appreciated by all scientific agronomists, viz: Agriculture in Some of Its Relations to Chemistry, by F. H. Storer, and Soils, their Formation, Properties, Composition, and Relations to Climate and Plant Growth, by E. W. Hilgard.

A very remarkable document dealing with the fertility of the soil and its conservation is found in the annual oration delivered before the Chemical Society of Philadelphia on April 14, 1798. There are only a few copies of this document in existence. One of the most interesting of these is a copy given to Thomas Jefferson by the author himself, and now in the Library of Congress. On the title page is written in ink "To Thomas Jefferson, with the compliments of the author." The theme of the oration is a sketch of the revolutions in chemistry, by Thomas P. Smith, and it is dedicated to Robert Patterson, A. M., professor of mathematics in the University of Pennsylvania. At a meeting of the Chemical Society on April 14 the following resolution was adopted: "*Resolved*, That a copy of Mr. Smith's learned and ingenious oration be requested for publication. Extract from the minutes. George Lee, Jun. Sec'ry."

The concluding portion of this oration is as follows:

> The only true basis on which the independence of our country can rest are agriculture and manufactures. To the promotion of these nothing tends in a higher degree than chemistry. It is this science which teaches man how to correct the bad qualities of the land he cultivates by a proper application of the various species of manure, and it is by means of a knowledge of this science that he is enabled to pursue the metals through all the various forms they put on in the earth, separate them from substances which render them useless, and at length manufacture them into the various forms for use and ornament in which we see them. If such are the effects of chemistry, how much should the wish for its promotion be excited in the breast of every American! It is to a general diffusion of a knowledge of this science next to the virtue of our countrymen, that we are to look for the firm establishment of our independence. And may your endeavors, gentlemen, in this cause entitle you to the gratitude of your fellow-citizens.

DEFINITIONS OF SOIL FERTILITY.

The measure of the fertility of the soil is its ability under given seasonal conditions to produce a crop. The magnitude of the crop in those conditions affords a safe basis of judgment. It is true a crop does not get its whole nourishment from the soil. The carbohydrate matter, of which the largest part of every plant is composed, is taken from water and the carbon dioxid in the air or dissolved in the water. It is a self-evident axiom that the absence of any one essential element of plant food renders the production of a crop impossible. The absolutely essential substances necessary to plant growth are water, carbon dioxid, potash, and phosphoric and nitric acids. Essential elements are sulphur, lime and iron, magnesia and silica, and other mineral elements usually found in soils are also generally met with in plants, but are not deemed essential.

The soil plays a double rôle in plant growth—first it furnishes the physical support of the plant, and second it provides directly or intermediately the lime, potash, phosphorus, nitrogen, and sulphur, without which complete plant development is impossible.

The fertility of the soil is of two kinds, viz, temporary and continuing. Temporary fertility represents that excess of available plant food found in virgin soils and which rapidly disappears under continuous cultivation without fertilization. Temporary fertility also represents that increased power of production which a soil manifests under special tillage or by the application of manure and fertilizers. Continuing fertility is that which the soil maintains without the addition of fertilizing material and below which continual cropping can not reduce it. This properly represents the natural barrier interposed to prevent present agriculture from robbing future generations. It can not be doubted that if all the fertility of the soil could be put into enormous crops, say for a period of fifty years, the natural rapacity of man, from which even farmers are not free, would not be slow to utilize the gift. Future generations would be left to starve if nature permitted the enrichment of the present one. The phrase "continuing fertility" does not necessarily mean that there is no change in the degree of fertility or that there is any hard and fast line between it and temporary fertility. Experience has shown that in the great majority of cases a fertile virgin soil subjected to the usual practices in vogue in this country rapidly loses its fertility until a certain minimum production is reached. It then remains in this state with but little change for a long time. This fact has also been scientifically established by the celebrated experiments conducted at Rothamstead.

Now, if I understand the purpose of this discussion it is not how to preserve this minimum fertility but, on the other hand, how to preserve the higher fertility as shown in most virgin soils. On two previous occasions I have discussed this problem in detail, viz, in my address as chairman of Section C, of the American Association at the Buffalo meeting in 1886,[a] and the other in an address as retiring president of the American Chemical Society at Baltimore.[b]

In the address first mentioned I say: "The exportation of agricultural products becomes, therefore, a slow but certain method of securing soil exhaustion, and this accounts for the fact that countries, or those portions of countries which are devoted to almost exclusive agricultural pursuits, thus causing a continuous exportation of agricultural products, become the homes not of the richest but of the poorest communities."

It would be useless to deny in this connection that our own country, with a soil enriched by centuries of accumulating nitrogen, has grown rich from its agricultural exports. But when the last of our virgin soil shall have been placed under cultivation a continuous stream of such exports will certainly impoverish the nation and reduce all who practice such agriculture to the condition which has already been reached by those who have for years grown tobacco, corn, cotton, and wheat on the same soil and sold the products without paying back to the field the percentage of profits which was its due.

On the other hand, the farmer who is fortunate enough to be permitted to patronize the home market, who sells his maize and takes home a load of manure, adds not only to the plethora of his purse but also to the fertility of his soil.

Thus in the light of agricultural chemistry we see clearly the deep scientific basis of the teachings of political economy which show the value of the home market. While, therefore, the statement made at the commencement of this address, that the chief factor in the prosperity of a country is its agriculture, remains in every sense true, yet from the data discussed it as readily appears that agricultural prosperity is most intimately connected with the advancement of every other industry. Agricultural chemistry teaches the farmer to welcome the furnace and the mill, for in their proximity he secures a sure return to his fields of the plant foods removed in his crops.

We have seen by the foregoing discussion that, without any artificial additions, the soil, excluding the subsoil, contains enough of the two most important and valuable mineral constituents of plants to produce an average crop annually for 250 years. In point of fact, however, the impoverishment of the soil takes place at a much slower rate than this theory would indicate. It would, indeed, be a sorry thought to consider that in a quarter of a millennium the agricultural area of the earth would be incapable of producing further yields. Doubtless much of this reserve food is brought from the subsoil, and if it be possible for the subterraneous stores of these materials gradually to work their way surfacewards, even the remote future need not fear a dearth of them.

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[a] Proceedings of the Am. Assn. Adv. Sci., vol. 35.

[b] Journ. Am. Chem. Soc., Jan., 1894.

There is also a certain conservatism in crops, a vegetable "good breeding," which prevents the growing plant from taking all the food in sight. As long as there is abundance the plant is a hearty eater, but when the visible quantity of food falls to a certain minimum it remains for a long time without any rapid diminution. This fact is well illustrated in the experiments of Lawes and Gilbert at Rothamstead, where wheat was grown on the same unmanured field for forty years in succession.

In the "Summary and general conclusions" derived from these experiments, these celebrated agronomists say: "A soil which in the ordinary course of agriculture would have received an application of manure before another crop was sown, has produced crops of wheat in succession, averaging 14 bushels per acre, solely by means of its existing fertility. * * * The stock of potash and phosphoric acid has been largely reduced. Although so much soil fertility has been removed, the stock that remains would appear to be sufficient to grow crops of wheat for a very long period; the produce, however, must, in process of time, necessarily be lower than it has hitherto been."

THE ROTATION OF CROPS.

The great utility of a proper rotation of crops in conserving the magnitude of the yield is one of the best known principles in scientific agriculture. Various and ingenious theories have been presented to account for this benefit. In this connection it seems to me desirable to point out the true cause of the benefit derived from the rotation of crops. There is nothing mysterious or occult in plant growth. As in the case of animals, plant growth consists in pure chemical transformations. There is no such thing as "vital principle" or "mysterious force," or "supernatural influence." Every operation is based upon the principles of chemistry. The course of the sap in the plant, the nourishment of the germ, the transformation of the carbon dioxid of the air, the building of inorganic into organic products, the building up and decomposition of plant materials are all governed by the laws of chemical science.

Attention has already been called to the fact that the sources of plant food are so distributed in nature that they become available little by little, thus securing for future generations the possibility of life which would be speedily denied them if soil fertility could be utilized within a few years. The well-known principle of the law of the minimum, it seems to me, is the true explanation of the benefit of crop rotation. If all crops used their foods in the same proportion, there could be little benefit derived from crop rotation, but as in the case of animals so it is with plants. Some animals live exclusively on flesh foods; others live exclusively on vegetable foods; others on mixtures of these foods in varying proportions. It is evident that if all animals lived on flesh foods starvation would soon take place. It is evident, further, that if all animals lived on vegetable foods the food problem would be immensely increased in difficulty, and if all animals lived on the same proportions of vegetable and animal foods there would be a stringency in some quarters due to the exhaustion of one or another of the principles of the foods. The same law holds good with the plant. While all plants live on essentially the same kinds of food, the quantities of any particular kind required vary in every plant. It is only necessary to study the life history of any one plant and compare it with the life history of another to show this fact. For instance, a study of the nutrition of wheat as compared with the nutrition of the sugar beet will indicate in probably an extreme manner the variations of the proportions of the various plant foods required. Hence if a crop, such as the sugar beet, is grown continuously on a field without the administration of any artificial food, the particular character of the plant food furnished by the soil which is most required is soon reduced to a minimum of production, while at the same time other varieties of plant food may still exist in abundant proportions. In this condition the sugar beet grows only with its minimum crop. If any cereal, such as wheat, be planted in the same field, all the elements necessary to the production of wheat may still be present in abundance and the maximum crop of wheat will be produced. Since plant foods are furnished constantly in soils chiefly by progressive decomposition and by capillary translation, the best results are necessarily secured by changing crops. This principle will account for the principal benefit secured by crop rotation. There are of course other factors, such as character of the cultivation, the variations of the bacterial flora, the increasing or decreasing acidity, which play a prominent but not a dominant rôle. But in each of these cases the general law of supply and the general law of the minimum hold good.

LOSSES DUE TO INSECTS.

PART I. INSECTS AS A CHECK ON AGRICULTURAL PRODUCTION AND AS A SOURCE OF WASTE TO ACCUMULATED SUPPLIES.

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INTRODUCTION.

The value of the farm products of the United States for the year 1907 is estimated by the Secretary of the United States Department of Agriculture at $7,412,000,000 at the point of production. Of this total $4,742,000,000 are plant products. The accumulated stores of previous years of such staples as the grains, tobacco, etc., will easily bring the value of plant products of this year, subject to loss from insects, to upward of $6,000,000,000. To one familiar with the work of important insect pests on farm crops, stored grains, and other stored products entering into this total, it is not difficult to approximate the probable shrinkage due to insects. The detailed description of such shrinkage which follows indicates that it will rarely fall below 10 per cent of the total value, and in the case of certain important farm staples may, in years of excessive damage, amount to 50 per cent. For the cereal grains and other important field crops a minimum 10 per cent rate of loss from insects has been adhered to. The rate of loss, however, is much heavier with certain other classes of farm products, such as truck crops and fruits, being certainly not less than 20 per cent for the former and 30 per cent for the latter. As will be indicated more exactly farther on, this resulted for the year 1907 in a shrinkage in value of all plant products of the farm of $552,500,000. To this must be added the injury occasioned by insect pests to farm products in storage, amounting to at least $100,000,000, making a total tax in 1907 of $652,500,000 on the plant products of the farm chargeable to insects, and this is approximately the annual tax which insects impose on such products in the United States. That this estimate, which at first may seem absolutely preposterous, has really a reasonable basis will be indicated, it is believed, by the more detailed consideration of the nature of the losses which follows.

BASIS OF ESTIMATES.

The estimate of losses is based on the farm price of the crop actually harvested, and does not, therefore, take into account the possible reduction in value which would follow the marketing of the larger crop. While it is true that prices are regulated by production, the factor of distribution, especially in the case of cereals, often predominates, so that large crops may bring good prices and small crops low prices. During the last fifteen years, for example, the price of wheat in this country has exhibited little if any relation to our own production. The bumper wheat crop of 1901 of nearly 750,000,000 bushels brought to the farmer 23 cents a bushel more than the crop of 1894, which was 300,000,000 bushels less, or but little more than half the production of 1901; and for several years the farmer has been getting higher prices for wheat on crops larger than the average.

Some definite means of estimating losses must be assumed, and any effort to scale down these losses by reckoning possible enhancement of the market price, in view of the conditions just cited, would come more in the category of pure guesswork and be open to quite as great objection as the plan adopted. As an offset to possibly enhanced values due to shrinkages occasioned by insects, moreover, are certain very legitimate items of cost. A very considerable item of loss properly chargeable to insects is the annual expenditure devoted to their control, which, except in the case of certain fruit and truck crops, has not been considered in the estimates. This amounts to a large percentage of the value of the crop in the case of orchard fruits, truck crops, and of such field crops as cotton and tobacco. In the case of the cereals, protection is chiefly secured by farm practices, such as rotation of crops, variations in the time of planting, etc., and this also applies, to some extent, to cotton, tobacco, and truck crops. In estimating the losses due to the codling moth, for illustration, it is shown that a sum of $5,000,000 a year is expended in spraying apple trees, allowing a cost of only 10 cents per tree for one-fourth of the bearing trees. In the case of citrus fruits the cost of gassing and spraying ranges from 10 cents to $1.50 per tree.

Another legitimate class of losses not included in the estimate is the secondary losses which necessarily result from diminished products. For example, the excessive reduction in winter wheat through the Hessian fly ravages in 1900 put a serious check upon milling operations throughout the region worst affected and caused very heavy loss in this field of industry. Similarly a shortage of cotton may so increase the values as to lead to the shutting down of cotton mills, as has been illustrated recently. A shortage of grains means a corresponding loss to railroads and other transportation companies and to shippers. In other words, any material shrinkage in an important product starts a train of losses to the end of the chapter, the total amount of which is quite beyond calculation or estimate.

The writer believes that these omitted items of loss will make good any difference of price which might result from the larger crops if insect damage were entirely eliminated.

Irrespective of the monetary consideration is the actual material loss in products, which is absolute so far as the consumer is concerned. From the standpoint of the producer, also, the action of injurious insects is to put a check on production, and the shrinkage of crops represents wasted effort. In other words, were it not for these pests, a lessened acreage and a saving in labor would produce an equivalent crop.

A general view of the relation of insect losses to the important staples is given in the table below. The value of plant products is based on the report of the Secretary of the United States Department of Agriculture for 1907. The last two columns, indicating the shrinkage due to insect work, are based on the crop actually harvested; that is to say, except for such damage the crop would have been 10 or 20 per cent greater.

Values of plant products for 1907 and losses chargeable to insect pests.

Product.	Value.	Percentage of loss.	Amount of loss.
Cereals	$2,378,000,000	10	$237,800,000
Hay	660,000,000	10	66,000,000
Cotton	675,000,000	10	67,500,000
Tobacco	69,000,000	10	6,900,000
Truck crops	[a] 340,000,000	20	68,000,000
Sugars	64,000,000	10	6,400,000
Fruits	[a] 220,000,000	30	66,000,000
Farm forests	[a] 150,000,000	10	15,000,000
Miscellaneous crops	[a] 189,000,000	10	18,900,000
Products in storage	....	....	100,000,000
Total	4,745,000,000	....	652,500,000

[a] Estimate only.

An explanation of the nature of the loss and method of computation for the different products as above classified follows:

INSECT DAMAGE TO CEREAL CROPS.

Only the losses to the two most important cereals, corn and wheat, will be discussed in this paper, as the injury to oats, barley, rye, etc., will average about the same percentage and need not be specifically analyzed.

INSECT DAMAGE TO CORN.

In point of quantity and value, corn is the leading cereal crop of the United States. Its annual farm value in later years has been upward of $1,000,000,000. While less subject to insect damage than wheat, the next most important cereal, the corn product would be considerably greater were it not for important insect pests. The work of several of these is obscure, and many farmers are entirely ignorant even of the existence of some of the worst enemies of this crop. In this last category falls the work of the corn root worm (*Diabrotica longicornis*), which ordinarily passes unnoticed, or at least is often misunderstood. The larva of this insect feeds on the roots of young corn, and in regions of bad attack may cause almost an entire loss of the stand. The corn root worm, together with one or two allied species working in substantially the same way, causes an annual loss of at least 2 per cent of the crop, or some $20,000,000.

Perhaps the next most important insect pest of this cereal is the bollworm or earworm. This insect, as shown by Mr. A. L. Quaintance, of this bureau, probably attacks from 90 to 100 per cent of the ears of sweet corn throughout the country, and in the South practically an equal percentage of the ears of field corn, as shown by actual counts in the field made during the years 1902 and 1903. The average loss in the number of kernels to an attacked ear is 15 per cent, or, if allowance be made for the smaller size of the terminal kernels, at least a loss of 7½ per cent. The percentage of loss is less in the great corn areas of the Northern and Middle States, but a 2 per cent loss for the United States chargeable to this insect is certainly well within the limits of actual damage, and would, for the corn crop of 1904, indicate a loss of over $20,000,000.

Of perhaps equal importance to this crop are the depredations of the chinch bug. Chinch-bug injury is, as a rule, more marked where corn is grown in the neighborhood of wheat or small grains, and in such cases the migration of the chinch bug from wheat to corn may often result in the total destruction of considerable areas of corn. The chinch bug is a strong flier also, and at the period of migration in midsummer corn is often attacked, the loss in the case of this cereal being, however, very much less than in the case of wheat. For the country as a whole, however, the loss from the chinch bug, taking one year with another, will probably be 2 per cent of the crop, or, estimating from the crop of 1904, $20,000,000.

Every year in different sections of the country there is notable injury to corn by such insects as billbugs, the various wireworms, cutworms, army worms, stalk borers, various species of locusts or grasshoppers, corn plant lice, and others, to a total of fifty fairly important species. These minor pests undoubtedly cause a loss of an additional 2 per cent, making a total annual injury of 8 per cent and indicating a loss of $80,000,000.

INSECT DAMAGE TO WHEAT.

Of the cereal crops of this country wheat suffers most from insect depredations. Of the large number of insects which depredate on this cereal, the three important species are the Hessian fly, the chinch bug, and the grain plant louse, using the latter term to include several allied species which work in much the same manner.

The chinch bug is notably a wheat pest, although its damage to other cereals and forage crops is very considerable. The losses from the depredations of this insect on wheat in single States have ranged between $10,000,000 and $20,000,000 in one year. A very reasonable average annual estimate of loss, taking the country as a whole, would be 5 per cent of the value of the wheat crop, which would indicate about $20,000,000 a year chargeable to this insect.

The Hessian fly is distinctly a wheat pest, although doing some damage also to rye and barley. The losses due to it will be considered in detail to indicate their nature specifically and to illustrate the exactness and reliability which may sometimes characterize records of this kind relating to particular pests of a single crop.

The season of 1900 is notable in Hessian-fly annals as exhibiting the most destructive work of this pest in recent years. The fly was very generally present throughout the main wheat-growing districts of the Ohio and Mississippi valleys, but its ravages were that year concentrated particularly in Ohio and Indiana. The statistics of the acreage and yield of wheat and the value of the crop for that year for the States mentioned reflect very plainly the loss occasioned by this pest. The wheat area in these two States in 1900 and the years immediately preceding was about 5,000,000 acres. Chiefly on account of the ravages of the Hessian fly more than half of this acreage (2,577,000 acres) had been abandoned and planted in other crops prior to May 1, 1900, as shown by the records collected by the Bureau of Statistics of this department. The abandonment was about 40 per cent for Ohio and 60 per cent for Indiana. The cost of the preparation of soil, planting, and seed wheat for this abandoned acreage is all that need be reckoned, inasmuch as it was possible to use the land for other crops, such as corn or oats. The loss in labor and material indicated will approximate $3.50 per acre, giving a total of over $9,000,000. Of the remaining wheat acreage, the average yield per acre for this year in Ohio was 6 bushels, as against 15.3 bushels for the year following, 14.2 bushels for the year previous, and nearly 17 bushels for the years 1897 and 1898. For Indiana, the yield per acre in 1900 was only 5.3 bushels, as contrasted with 15.8 bushels for 1901, and 15.6 and 9.8 bushels, respectively, for 1898 and 1899. In other words, a decrease of nearly two-thirds in the yield per acre is shown for these two States for the area in wheat which was left for harvesting. The Hessian fly does more or less damage every year, which reduces the average yield per acre, and, therefore, if such damage be eliminated the average yield per acre should be in the neighborhood of 15 bushels, indicating a loss for that year of nearly 10 bushels per acre for the area harvested, or, for the two States, of 24,230,000 bushels of wheat, of approximately a farm value (at the low price for that year) of $15,000,000. This loss, combined with the $9,000,000 indicated for abandoned acreage, gives a total direct loss for Ohio and Indiana of over $24,000,000. These figures, enormous as they are, are based on the careful statistical records of the acreage, yield, and prices of 1900 collected by the statistician of the department, working entirely independently of the Bureau of Entomology.

During this year the damage in other wheat-producing States was notable. For example, more than 20 per cent of the planted area of Michigan was abandoned, and lesser amounts in other States, with great shrinkage in the yield which was actually harvested. The loss, therefore, for this single season due to the Hessian fly undoubtedly approached $100,000,000.

The losses occasioned by this insect, while showing great fluctuation, as indicated, are an annual tax on the wheat crop. Except in cases of exceptional severity they pass, however, comparatively unnoticed. For example, the Hessian fly was not especially complained of in 1904, yet the agent investigating the insect enemies of cereal crops in the Ohio Valley reported that many fields showed injury to the extent of from 50 to 75 per cent. In comparatively few years this insect causes a loss less than 10 per cent of the crop, or the equivalent of a shrinkage of over 50,000,000 bushels in the yield, or, on the valuation of the crop for 1904, of over $40,000,000.

The losses due to grain plant lice are often very heavy, as may be illustrated by the extraordinary invasion of the so-called green bug in Texas and Oklahoma in the season of 1907. Statistics of these two States only are given, but the green bug spread its damage extensively into Kansas and was the occasion of more or less loss to small grains throughout the United States east of the Rocky Mountains. In Texas and Oklahoma, however, the damage was excessive, and over vast areas the wheat and oat crop was totally destroyed. The shortage of these crops in these States is to be attributed practically to this one source, as the conditions were otherwise favorable for an average yield. As shown by the records of the Bureau of Statistics of this Department, there was a reduction of over 24,000,000 bushels in yield of wheat over the preceding year (1906) from a similar acreage planted for Texas and Oklahoma, and a shrinkage of more than 35,000,000 bushels of oats. The grain thus lost represents an approximate farm value of $32,000,000. Some of this loss was made good by the replanting of the ravaged fields in other crops, but the cost of the preparation of the soil for planting and the seed grain for the abandoned acreage (nearly three-fourths of the area planted), and the very much lessened yield of the acreage actually harvested, makes a large percentage of this amount an actual loss. The plant louse occurs every year throughout the Mississippi Valley and eastward, always inflicting more or less damage, and with a favorable season may any year cause a loss similar to that witnessed in Texas and Oklahoma in 1907. The average annual loss from this and other plant lice certainly amounts to 2 or 3 per cent of the wheat crop.

The many other insects depredating on wheat, including grasshoppers, the wheat midge, several species of sawflies, and the cutworms and army worms, will swell the total of loss to at least 20 per cent of the crop. In other words, were it not for the attack of these pests the wheat crop would be one-fifth greater than it now is, or would have an additional value of approximately $100,000,000.

The insect damage to other cereal crops probably falls short of 10 per cent. A 10 per cent average, however, for all the cereals is certainly a reasonable one and is the basis of the loss indicated in the general table.

INSECT DAMAGE TO HAY AND FORAGE CROPS.

The damage by destructive insects to hay and forage crops is more obscure and less generally understood than in the case of any other farm products. Certain of the larger insects depredating on hay and forage crops are commonly known. These include the various species of locusts or grasshoppers, army worms, and cutworms. Very little understood and generally overlooked, however, are the webworms and small grass worms (*Crambus* spp.) which work about the base or roots of the plants, and which are so abundant that at certain seasons the moths flit up in front of one at every step. Swarming also in grass lands are many species of minute leaf hoppers which reduce the yield enormously, their small size being more than offset by their prevalence and numbers. Obscure, but very important also, are the white grubs which work on the roots and often kill the grass outright over large areas, and everywhere tax production heavily. In the same class in habit are the meadow worms or leather jackets, the grass-root feeding larvæ of the crane flies. A 10 per cent shrinkage from these and other pests in grasses and forage plants is a minimum estimate.

INSECT DAMAGE TO COTTON.

The principal insect depredators on cotton are the cotton-boll weevil, the bollworm, and the leaf worm. Many other insects, however, inflict minor damage. The loss chargeable to the boll weevil, from the very conservative estimate of Mr. W. D. Hunter, the agent charged with the study of this insect in Texas, represents, for the year 1907, some $25,000,000.

The bollworm is chiefly destructive in the southwestern cotton-producing States of Mississippi, Oklahoma, Arkansas, Louisiana, and Texas, causing a damage of from 2 to 60 per cent of the crop; it has been very conservatively estimated by Mr. A. L. Quaintance at 4 per cent of the crop and indicates an annual loss of some $12,000,000. East of these States comparatively little damage is done by the bollworm.

The cotton-leaf worm in years of excessive damage, before arsenical poisoning was a common practice, caused a loss of $20,000,000 to $30,000,000. The present damage is very much reduced, but with the increased acreage of cotton an annual loss of from $5,000,000 to $10,000,000 may be conservatively estimated.

Without counting the losses due to a host of minor insect depredators, we have already a total annual loss of more than $40,000,000 chargeable to three important insect pests of this staple.

INSECT DAMAGE TO TOBACCO, TRUCK CROPS, SUGAR CANE, ETC.

Detailed statements relative to insect losses to the crops enumerated above will not be attempted in the space at command. All are subject to attacks of important insect pests, and a reasonable estimate of the annual damage is 10 per cent of the value of the first and last named crops, and fully 20 per cent in the case of truck crops. Vegetables and other truck crops are especially subject to insect injury; furthermore, there is always a large expenditure in the control of insects, the items of which and of actual damage together probably making the tax due to insects double the normal 10 per cent rate.

INSECT DAMAGE TO MISCELLANEOUS CROPS.

A great many minor crops enumerated in the census of 1900 can not be discussed separately; consequently, the valuation of the crops is lumped together and a 10 per cent loss chargeable to insects estimated on the whole, which seems reasonable in view of the examinations already made of the more important farm products.

INSECT DAMAGE TO STORED PRODUCTS.

The estimates given in the foregoing discussions relating to vegetable products give the shrinkage due to attacks of insects to growing and maturing crops. After these crops have run the gauntlet of insect enemies during their entire period of growth, notably the cereal and forage crops, tobacco, and certain truck crops, they are still subject to the inroads of another class of insect depredators while in storage on the farm, or, in greater accumulations, in elevators and mills, or, again, while in transit, especially in the case of long shipments by sea. The cereals are kept in storage until consumed, which means a considerable period for the bulk of the crop. The various grain weevils and beetles, flour moths, and other insect pests which depredate on stored grains frequently cause great losses, and an estimated injury of 5 per cent is a reasonable and probably minimum figure. Computing this percentage, therefore, on the valuatio of the cereal products for 1907 we have an annual loss of more tha $100,000,000.

The location of food products for human consumption is in th house storeroom and kitchen, and often this last opportunity fo insect damage is improved by various species of the stored-grai pests already referred to. Animal products are attacked by larde beetles, ham beetles, etc.; fruits by various fruit and vinegar flies; an woolens or household furnishings by carpet beetles, clothes moths silver fish, etc.

Cured tobacco is especially subject to insect attack and damage, th most important source of injury being a minute insect known as th cigarette beetle, which not only eats into cigarettes but into all othe forms of cured tobacco. It is now widespread in America, occurin in practically all factories, warehouses, and retail establishments, an is frequently the cause of very heavy losses.

In the general table a total loss of $100,000,000 is indicated fo insects attacking stored products. This is covered by the loss fo cereal products alone, and if the other items of loss just enumerate were included a considerable increase in the estimate could legitimately be made.

CONTROL OF INJURIOUS INSECTS.

The enormous annual loss which may now be fairly charged t insect pests can be very much limited by the more general adoptio of known methods of control and by thoroughgoing investigation to discover other practicable means of prevention. In no country i the world has the problem of insect control been more energeticall taken up than in the United States, both in the work of the Burea of Entomology of the United States Department of Agriculture an of the state and experiment station entomologists of the variou States. The methods of controlling important insect pests whic have resulted from the studies of the last twenty-five years, and whic have been adopted by the more progressive farmers and fruit growers have already put a large limitation on insect losses. As a genera proposition, fruit growing in this country would practically come t an end if sprays and other means of control, which have resulte from the studies of the problem by experts, were discontinued, and vast increase in the losses to cereals and other crops and to anima products would result from neglect of known measures applying i these fields.

As illustrating the saving from insect losses now effected and pointing to still greater ones, which will come as a result of future wor and the more general adoption of known methods, a few commo examples may be given. The cotton worm, before it was studied an the method of controlling it by the use of arsenicals was made common knowledge, levied in bad years a tax of $30,000,000 on the cotto crop. The prevention of loss from the Hessian fly, due to the knowledge of proper seasons for planting wheat, and other direct an cultural methods, results in the saving of from $100,000,000 to $200,000,000 annually. Careful statistics show that the damage from th codling moth to the apple is limited two-thirds by the adoption o arsenical sprays, banding, and other methods of control, representing a saving of from $15,000,000 to $20,000,000.

The existence and progress of the citrus industry of California were made possible by the introduction from Australia of a natural enemy of the white scale, an insect pest which was rapidly destroying the orange and lemon orchards, this introduction representing a saving to the people of that State of many million dollars every year. The rotation of corn with oats or other crops saves the corn crop from the attacks of the root worm to the extent of perhaps $100,000,000 annually in the chief corn-producing regions of the Mississippi Valley. The cultural system of controlling the boll weevil is already saving the farmers of Texas many millions of dollars, and, in fact, making the continuance of cotton growing possible, and scores of similar illustrations could be cited.

PART II. INSECT DAMAGE TO FRUITS.

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INTRODUCTION.

As indicated in an introductory paragraph in Part I, the insect injury to orchard and small fruit is exceptionally heavy, and in spite of the corrective measures there is a tax of at least 30 per cent on production. Remedial measures are of the greatest importance in this field, and were it not for the insecticide and other treatment now practiced the commercial fruit interests of this country would be practically annihilated. In addition to the horde of native species which have in great measure left their native wild food plants and attack orchard products, many of the most serious fruit insect enemies of the Old World have been introduced into this country, often without their natural checks, for which and other reasons they have here become excessively injurious. The control of most orchard insects takes the form of spraying, and while this is relatively very expensive, fruit spraying yields a larger percentage of benefit than is the case with many other crops.

The detailed examination of the subject which follows covers the leading insect enemies of the principal deciduous fruits, such as the codling moth, San Jose scale, peach-tree borers, grape phylloxera, etc. The citrus and subtropical fruits have not been specifically considered, but with these the rate of loss, together with the cost of protective treatment, is fully as heavy as with the deciduous fruits. A total insect tax on deciduous fruits of more than $66,000,000 is indicated, and this is really a moderate estimate, as will be seen from the discussion of the several items entering into this total. The cost put down for spraying trees and the losses to fruit are minimum charges, and are very generally exceeded in actual orchard practice and experience.

THE CODLING MOTH.

The codling moth has been depredating on the American apple crop for upward of one hundred years, and during this period has destroyed fruits to the value of several hundred millions of dollars. Within the past twenty years a very large sum has been expended in its control.

The average annual apple crop from 1897 to 1907, as shown by statistics obtained by the American Agriculturist, is approximately 37,000,000 barrels. Assuming that there is a 25 per cent loss of fruit from this species, the figures of yield given represent three-fourths of the total crop—that is, the shrinkage in yield is about 12,330,000 barrels, which, with a valuation of $1.25 per barrel, represents about $15,500,000. Deducting from this amount the possible value of the fruit for cider, vinegar, etc., at 30 cents per barrel, there is a net loss of $11,750,000.

Assuming that but one-fourth of the total number of apple trees are sprayed each year, and at a cost of 10 cents per tree, the cost of treatment is about $5,000,000.

The total annual tax of this species to the apple growers of the United States thus amounts to about $16,750,000, as explained more in detail below:

DAMAGES BY THE CODLING MOTH.

(*Carpocapsa pomonella.*)

In estimating the annual loss from this insect to apple crop, the American Agriculturist figures of crop were used, and the average crop of the past ten years was taken as a basis:

Average crop, 1897 to 1907, inclusive (barrels)	37,000,000
Estimated that only one-half of total number of trees are in bearing any one year (off year, cold, etc.), crop from, approximately (trees)	100,000,000
Estimated that only one-half of this number of trees are sprayed	50,000,000
Estimated that in unsprayed orchards there is a loss each year of 50 per cent of crop.	
Shrinkage in yield, 25 per cent of whole crop, or 50 per cent of crop on the 50,000,000 unsprayed trees (one-third of 37,000,000 barrels)	12,333,333
Value of shrinkage, at $1.25 per barrel	$15,416,666
(Average price per barrel for past ten years at principal eastern markets was $2.65.)	
Less value of culls, at 30 cents per barrel	3,699,999
Net loss on crop	11,716,667
At 10 cents per tree, cost of spraying 50,000,000 trees	5,000,000
Present loss and cost of treatment	16,716,667

THE SAN JOSE SCALE.

The outlay necessary to bring an orchard to bearing age is considerable, amounting under favorable conditions of management to from 50 cents to $1 per tree. The destruction of trees by scale or other causes before fruiting begins, or later, represents therefore a loss of invested capital aside from the loss of possible dividends from the fruit produced. Losses from the San Jose scale have been occasioned largely by the wiping out of capital invested in orchards by the destruction of the trees. Since its introduction into California in the early seventies, and its appearance in the East some fifteen years later, losses of this character to orchards and other plants have been perhaps not less than fifty or sixty million dollars.

A conservative estimate of its injuries at the present time indicates that of the 350,000,000 trees of the more important deciduous fruits, as given in the 1900 census, about 80,500,000 are infested. It is believed that three-fourths of this number, or 60,000,000, are now being treated, resulting in the preservation of trees worth at least $46,000,000.

The annual loss resulting from failure to spray amounts on the same basis to about $5,000,000. The cost of treating the 60,000,000 trees, at 9 cents each, is about $5,500,000, aggregating a total annual charge against this species of $10,500,000, as detailed below.

DAMAGES BY THE SAN JOSE SCALE.

(Aspidiotus perniciosus.)

The number of trees subject to infestation as given by the 1900 census was taken as a basis. The number of trees infested was determined by estimating the percentage of infestation in the various States where the scale is known to occur.

Apple trees infested	40, 383, 339	Now sprayed	30, 287, 505
Peach and nectarine	27, 911, 032	Do	20, 933, 274
Pear trees infested	3, 116, 884	Do	2, 337, 663
Plum and prune infested	9, 014, 316	Do	6, 760, 737
Total	80, 425, 571	Total	60, 319, 179

Value of orchard interest now saved by spraying:	
30,297,505 apple, at $1 per tree	$30, 279, 505
20,933,274 peach and nectarine, at 50 cents	10, 466, 637
2,337,633 pear, at 75 cents	1, 753, 224
6,760,737 plum and prune, at 50 cents	3, 380, 368
	45, 879, 734
Loss from San Jose scale:	
One-fourth of infested apple trees, not sprayed, 10,095,834, at $1 each	10, 095, 834
One-fourth of infested peach and nectarine trees, not sprayed, 6,997,758, at 50 cents	3, 488, 879
One-fourth of infested pear trees, not sprayed, 779,221, at 75 cents each	584, 415
One-fourth of infested plum and prune trees, not sprayed, 2,253,579, at 50 cents each	1, 126, 798
	15, 295, 917
Assuming that only one-third of these trees die each year, annual loss becomes	5, 098, 639
Cost of treatment, 60,319,179 trees, at 9 cents each	5, 429, 626
Total annual loss of trees and cost of treatment	10, 528, 265

PEACH TREE BORERS.

Throughout its area of culture the peach is subject to attack from *Lepidopterous larvæ*, which feed on the inner bark, at the base of the tree, on the roots, or along the trunk. Young trees are especially injured and often killed, and older trees are often so weakened that normal crops are not produced. Using the 1900 census figures as a basis, at a valuation of 50 cents per tree and an estimated injury of 10 per cent, the losses from this species become $5,000,000.

There is also a large expenditure in labor in worming trees (the method principally relied upon to control the species), amounting perhaps to at least $1,000,000, making a total charge against this species of $6,000,000.

DAMAGES BY PEACH TREE BORERS.

(*Sanninoidea exitiosa; S. opalescens; Synanthedon pictipes.*)

The number of trees as given by the 1900 census was taken as a basis.

Number of peach and nectarine trees approximately	100,000,000
Value, at 50 cents per tree	$50,000,000
Estimated an annual shrinkage in value of 10 per cent	$5,000,000
Estimated cost of treatment, mostly digging out	1,000,000
Total	$6,000,000

GRAPE INSECTS.

The grape suffers severely from insect attack. The *Phylloxera* in California, to which State its injuries are principally confined, causes an estimated annual deterioration in condition of vineyards of not less than 5 per cent. On this basis its injuries represent a loss of about $3,500,000.

The grape root worm for some years has threatened the grape industry in the Erie and Chautauqua grape belts in New York and Pennsylvania, and has done a large amount of damage in Ohio. Considering its injuries in this territory only, an estimated annual deterioration in the condition of vineyards of 10 per cent results in the loss of something more than $1,750,000. If to this be added all expenditures for treatment, there is a total of over $2,000,000 which this species taxes the grape growers of this limited territory.

The grape leaf hopper, another important enemy of the vine, occurs all over the United States, and is present in vineyards every year, in many instances being excessively destructive. At the low estimate of injury of 2.5 per cent for the United States as a whole, the deterioration in condition of vines resulting from the attack of this species is about $2,250,000. There are numerous other grape pests that locally often become seriously destructive, as the rose bug, grape berry moth, flea beetle, leaf caterpillars, etc. The total loss from these several pests of $1,000,000 each year, including money spent in their control, will be quite conservative. The annual loss throughout the country to vineyards therefore is about $8,750,000.

DAMAGES BY GRAPE INSECTS.

[Figures of 1900 census were taken as a basis.]

Phylloxera.

Number of vines in California	90,686,458	
Value, at 75 cents per vine	$68,014,843	
Estimated 5 per cent annual shrinkage in value of vineyards from *phylloxera* attack		$3,400,742

GRAPE ROOT WORM (*Fidia viticida*).

Number of vines in Pennsylvania, Ohio, and New York (principal area now seriously injured)	37,801,289	
Value, at 50 cents per vine	$18,900,644	
Estimated 10 per cent reduction in value		$1,890,000
Cost of treatment		200,000

GRAPE LEAF HOPPER (*Typhlocyba comes*).

Total number vines in the United States	182,333,064	
Value, at 50 cents per vine	$91,166,532	
Estimated 2½ per cent reduction in value		$2,279,163

Practically no treatment is given.

MISCELLANEOUS GRAPE INSECTS (ROSE BUG, BERRY MOTH, CATERPILLARS, ETC.).

Estimated annual injury, and cost of treatment for these several species	$1,000,000
Total for grape insects	8,769,905

THE PLUM CURCULIO.

The plum curculio is a native species and from earliest times has depredated upon stone fruits, and during the past fifteen or twenty years its injuries have become very important. This insect is confined to America so far as is known, and in the United States does not occur west of about the one hundredth meridian. Taking into account its distribution and its injuries to the apple crop in the Middle West and eastern States, on the basis of a 10 per cent reduction in yield, there results a loss of about $3,250,000. Assuming a loss to the peach crop of 33 per cent, the injuries to peaches, including the cost of remedial work, brings about a loss of somewhat more than $4,000,000. On the basis of a 50 per cent reduction in yield of plums and prunes throughout the infested territory, including the cost of treatments, there is a loss of about $1,250,000.

The total annual loss to its several food plants amounts to about $8,500,000.

DAMAGES BY PLUM CURCULIO.

(*Conotrachelus nenuphar.*)

APPLE.

[The figures for the apple crop in the following estimate were furnished by the American Agriculturalist.]

Average crop, 1897 to 1907, in the infested territory (barrels)	34,292,700
Estimated shrinkage of first-class fruit, 10 per cent	3,429,270
Value, at $1.25 per barrel	$4,286,587
Value of fruit as culls, at 30 cents per barrel	1,028,781
Total	$3,257,806

On apples this insect receives but little if any treatment aside from that given in codling-moth treatments.

PEACH.

There are no available figures on the yield of peaches. It was thus necessary to determine this as accurately as possible on the basis of the number of trees and a conservative yield which each should give.

Number of trees in infested territory	90,931,542
Assuming that one-fourth bear every year, producing an average of 1 crate per tree, valued at 50 cents, net value	$11,366,443
Estimated annual loss of 33 per cent	$3,788,814
Cost of spraying, jarring, etc	300,000
Total	$4,088,814

PLUM, PRUNE, ETC.

There are likewise no figures on the yield of the plum, prune, etc., and the yields of these fruits were determined in a similar manner.

Number of trees in infested territory	15,906,398
Assuming that one-fourth bear every year 1 crate per tree, at 50 cents value	$1,988,299
Estimated annual loss of 50 per cent	$994,149
Cost of treatment, spraying, jarring, etc	250,000
Total	$1,244,149

TOTALS.

Apple	$3,257,806
Peach	3,788,814
Plum, prune, etc	994,149
Total	$8,040,769
Cost of treatments	550,000
Grand total	$8,590,769

LOSSES FROM MISCELLANEOUS FRUIT-TREE INSECTS.

In addition to the more notable insect pests previously indicated, there is a large number of species which in the aggregate cause a very great injury to fruit or tree. Thus, for miscellaneous apple insects, a conservative estimate indicates that about $10,000,000 are lost annually from the attack of such species as canker worms, apple-tree borers, woolly aphis, etc. The pear crop suffers from pear thrips, pear psylla, codling moth, etc., aggregating in all a loss per year of about $1,350,000.

The loss to stone fruits from miscellaneous insect pests is found to be somewhat more than $3,650,000.

Cranberry culture is a relatively small and specialized industry; nevertheless, the losses from insect attack in proportion to the value of the crop is high, amounting to perhaps not less than 25 per cent. Using as a basis the figures furinshed by the American Agriculturist as to yield, the loss from insect attack to the fruit and vine amounts to about $400,000 annually.

The losses to the several crops mentioned from these miscellaneous insects thus total about $15,400,000.

The details for these several calculations are given below.

LOSSES FROM MISCELLANEOUS INSECTS NOT CONSIDERED IN OTHER CALCULATIONS.

Figures of 1900 census taken as a basis except in the case of cranberry insects. Here the figures of yield of fruit as given by the American Agriculturist were used.

Miscellaneous apple insects.

Number of apple trees	201,798,642
Valuation, $1 per tree	$201,798,642
Assuming a total annual injury of 5 per cent each year from such insects as canker worms, woolly apple aphis, green aphis, apple-tree borers, caterpillars, oyster shell and scurfy scales	$10,089,932

Miscellaneous pear insects.

Number of pear trees	17,716,184
Valuation, 75 cents per tree	$13,286,138
Assuming a total annual injury of 10 per cent from such species as pear thrips, pear psylla, pear slug, codling moth, curculio, etc	$1,328,613

Cranberry insects.

The average annual yield of cranberries during the past 4 years was (bushels)	1,057,750
Valuation, $1.50 per bushel	$1,586,625
Assuming a total of 25 per cent loss annually from such species as the yellow and black-head cranberry worms, the fruit worm, etc.	$396,656

Loss from miscellaneous insects to all stone fruits.

Total number of trees (peach, plum, prune, cherry, etc.)	147,753,746
Valuation, 50 cents per tree	$73,876,873
Estimated total loss of 5 per cent to value of trees annually	$3,693,843

DECIDUOUS FRUIT INSECTS.

Summary of total losses, including cost of treatment.

Codling moth	$16,716,667
San Jose scale	10,528,265
Peach-tree borers	6,000,000
Grape insects	8,769,905
Plum curculio	8,590,769
Miscellaneous apple insects	10,089,932
Miscellaneous pear insects	1,328,613
Cranberry insects	396,656
Miscellaneous stone fruits	3,693,843
	$66,114,650

RELATIONS OF BIRDS AND MAMMALS TO THE NATIONAL RESOURCES.

By Dr. C. Hart Merriam,
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INTRODUCTION.

In taking stock of our national resources and considering ways and means for their conservation, it should not be overlooked that an important part of the national assets consist of our insectivorous and game birds, our splendid game animals, and our native fur bearers.

VALUE OF BIRDS ON THE FARM.

Birds at all times and in all places are of direct interest to man. Some prey upon the products of man's husbandry, but by far the greater number prey continuously upon insects and rodents—the ever present enemies of agriculture and forestry. While it is impossible to represent by figures the value of our insectivorous and predatory birds, or to present in the form of statistical tables the number of millions saved annually by their labors, it would be a shortsighted policy indeed that would sanction depletion of their ranks. It is safe to say that upon their presence and well-being depend the existence of our forests and the possibility of successful agriculture. In most States an enlightened policy with regard to insectivorous birds already prevails;.and there is a growing sentiment also in favor of adequately protecting game birds, not only for their food value and as objects of pursuit by sportsmen, but for their demonstrated value as destroyers of insects, in which capacity some of them take first rank. The recognition of their importance in the latter rôle is comparatively recent, and much remains to be done before the public is educated to an understanding of the nature and full extent of their services, and the losses that will inevitably follow serious diminution of their numbers.

A striking illustration of the value of certain of our native birds and mammals in an emergency was afforded during the invasion by field mice of the alfalfa districts of Nevada in 1907, when mice in the Humboldt Valley increased till in places they reached the astonishing total of 12,000 to the acre, and completely destroyed the alfalfa fields. Several species of hawks and owls, many ravens, gulls, and herons, and numerous foxes, skunks, and coyotes speedily assembled and took up permanent residence in the infected district, where they fed almost wholly on the field mice. Though inadequate by themselves to suppress the plague, they contributed important aid, and had not their numbers been previously reduced by years of persistent persecution, it is almost certain that no plague would have occurred, as they would have prevented the increase of the mice. Furthermore, after the mice had been greatly reduced in numbers by systematic and persistent poisoning (in February, March, and April), they continued to decrease under the continuous attacks of their natural enemies until by August they were actually scarce—indicating the efficiency and value of the service rendered by predatory birds and mammals.

VALUE OF INSECTIVOROUS AND THE SMALLER PREDATORY MAMMALS.

The value of our insectivorous mammals, and of those whose food consists largely of destructive rodents, is less generally understood, and the labor of protecting and preserving them for the benefit of future generations of farmers is rendered correspondingly difficult. The lesson that every badger in Wyoming, Colorado, Texas, and other western States has a distinct money value to the public, and that the wanton slaughter of one is a crime against good citizenship, is as yet unlearned by the majority of the population. Foxes, skunks, weasels, and in certain regions even coyotes, have their appointed places on the force of nature's policemen, and a knowledge of the part they play and of the nature and extent of the good they do, as well as of the harm, should be universal.

VALUE OF GAME ANIMALS.

Elk and deer, once so numerous and widespread in the United States, have become so diminished in numbers that to the bulk of our citizens venison has become only a tradition. But by the establishment of game preserves, national parks, and national forests, and by the enactment of wise legislation the scale has been already turned, and the perpetuation of these, the most valuable of our large game animals, seems assured. If, however, they are to retain their place among the national resources and are to become a source of pecuniary profit, something more is necessary than to provide for their continued existence. Since they are among the easiest of animals to domesticate, it is believed, and indeed it has been already demonstrated, that they can be reared in small inclosures and on tracts of brushy land not fit for cultivation. Thus extensive tracts of waste land may be put to profitable use, and at the same time our decreasing meat supply may be materially augmented and its price lowered so as to bring fresh meat within the reach of a considerable part of the population now unable to procure it. One deer breeder states that 20 deer may be kept at the cost of keep of a single Jersey cow.

Value of wild game.—The number of wild deer killed annually in the United States is not known, but the annual kill in six of the Northeastern States (Maine, New Hampshire, Vermont, New York, Pennsylvania, and Michigan) is about 35,000. The resulting venison at 20 cents per pound is worth considerably more than a million dollars. To this should be added the value of hides, trophies, and other products of deer. Bear also are killed in these States, and have a material annual value. Besides, in Maine, about 300 moose are killed annually, the meat, hides, and trophies of which are worth at least $25,000.

In the States west of the Mississippi Valley the game mammals comprise several kinds of deer, elk, moose, antelope, mountain sheep, mountain goat, and bear, and the annual kill is very large, but exact statistics as to numbers and values are lacking.

Game birds, including ducks and geese, snipe, plover, and other shore birds, and the various kinds of grouse and quail, are shot in great numbers in every State in the Union, and in the aggregate have an enormous food and pecuniary value.

The annual revenue from hunting licenses is large and is steadily growing. In 1907 resident licenses were required in 21 States, nonresident in 43. From the rapidity with which the license system is spreading, it is obvious that in a very few years it will be general and that the annual revenue from this source alone will exceed $3,000,000—a sum considerably in excess of that required for the support of an ample warden service; so that the returns from sale of licenses will be a source of direct revenue to the State.[a]

VALUE OF WILD FUR-BEARING ANIMALS.

North America was formerly the richest fur-producing region in the world, but now the stock of fur-bearing animals is greatly depleted, and the supply falls far short of the demand. Still, the annual export of raw furs from the United States is valued at from $7,000,000 to $8,000,000, and the furs retained for home manufacture reach an even higher figure, so that it is probably within bounds to say that the present value of the annual catch of furs in the United States is between $15,000,000 and $20,000,000. The growing scarcity of the more valuable fur bearers has produced in the lower grades a great increase in both demand and price. What is needed in the case of this group of mammals is wise husbanding of the wild stock, which everywhere is diminishing under the growing demand for furs and the rapid encroachment on their original domain by our ever-expanding civilization. Under proper restrictions, the stock of fur-bearing animals, particularly in mountainous regions and in the national forests, may, without cost for maintenance, be brought to yield a large annual revenue.

It is fortunate that one of the most valuable of the fur bearers, the silver fox, can be reared in a semidomesticated state, and it is believed that the industry of fox farming is likely to prove a permanent occupation in northern districts where the fur attains its best development.

LOSSES FROM DESTRUCTIVE RODENTS.

Another important lesson to be learned is the need of cooperative effort in reducing the numbers of the small rodents that prey upon our field and garden crops, nursery stock, and planted seeds. The annual losses to agriculture from the ravages of our native rodents—chiefly ground squirrels, gophers, rabbits, prairie dogs, and field mice—amount to about $37,000,000, to which must be added an even larger sum, estimated at nearly $56,000,000, for the losses caused by European rats and house mice. These small rodents—singly insignificant, collectively an unmitigated pest—are everywhere a steady drain on production, and in places threaten the very livelihood of the small farmer. To rid restricted areas of them is easy, but attempts to rid large areas often fail simply for lack of the necessary cooperation. As at present conducted the war against them is never ending, because when destroyed on a given tract others quickly come in from adjoining lands, so that the work must be repeated again and again, entailing large expenditures without permanent results.

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[a] In Illinois the revenue from sale of licenses in 1907 was $145,905, exclusive of the cost of collection. In California the revenue from sale of licenses in 1907 was $118,427. The total sum actually available for game protection in 1905 was about $1,000,000.

LOSSES FROM THE LARGER CARNIVOROUS MAMMALS.

It has been estimated by stockmen that in Wyoming alone the losses from predatory animals—wolves, coyotes, and cougars—amount to $1,000,000 a year. This is about 3 per cent of the total value of the stock of the State. Assuming that the percentage of loss in the other States similarly infested ranges from one-tenth of 1 per cent to 2 per cent of the value of the stock, the annual loss to the United States is $13,844,000. This estimate does not include the value of game animals killed by carnivorous mammals, which aggregates several million dollars yearly. When the methods of destruction and repression recommended by the Biological Survey and put into practice by the Forest Service are extended over the wolf-infested country, about $7,000,000 may be saved annually.

This report shows that by the preservation and increase of our useful birds and game animals, and by the application of methods developed by the Biological Survey for the destruction of noxious species, millions of dollars may be saved annually; while the breeding of fur-bearing animals and the raising of deer and other game for market suggest what can be done by artificial means to increase natural resources now on the verge of exhaustion.

THE DEVELOPMENT OF GAME AS A NATURAL RESOURCE.

The game of the United States has never been systematically developed. The supply has usually been treated as inexhaustible, to be appropriated or destroyed at the whim of the individual, regardless of the future or the rights and interests of others, and only recently and in a few States has it been developed for the benefit of the people in general. The results of these wasteful methods are matters of common knowledge and are well exemplified in the case of the buffalo.

The actual destruction of the buffalo occupied less than twenty years, as shown by the following estimates of wild buffalo in the United States:[a]

1871 (Hornaday)	5,000,000
1889 (Hornaday)	285
1897 (practical extermination outside of parks)	---
1903 (Baker)	34
1908 (Hornaday)	25

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[a] Including the wild herd in Yellowstone National Park as follows: 1889, 200; 1903, 34; 1908, 25.

These figures show clearly the rapidity with which an animal of commercial value may be practically exterminated. What is true of the buffalo is true also, though in less degree, of several other kinds of big game, and of the wild pigeon. Owing to an awakening of public sentiment, destruction has recently decreased to an appreciable extent, and some kinds of game are now more abundant than they were a few years ago. Low-water mark for game in general probably occurred in the early nineties, and is usually placed about 1895, since when, as a result of protection, most species have held their own or have even increased.

CAUSES OF DEPLETION.

The chief causes of depletion may be briefly summarized as: (1) Killing without provision for maintaining the breeding stock; (2) killing during the breeding season, or, in the case of migratory birds, en route to the breeding grounds; (3) killing without limit.

BETTERMENT.

The means of betterment of present conditions are clearly indicated by the causes of destruction just mentioned, and may be stated as follows: (1) Absolute protection during the period of reproduction, and, in the case of migratory game, during the spring journey to the breeding grounds; (2) careful adjustment of the open season so that the annual kill shall not quite equal the annual increase; (3) reasonable regulation of the methods and extent of killing; (4) provision for rearing game in captivity or otherwise, and for caring for wild stock during winter; (5) provision of adequate means for establishing and maintaining the work of game preservation.

The need for effective protection and the best means of securing it are well understood. The chief obstacle is one of finance, and this is being rapidly overcome by a system of hunting licenses which already has been put into successful operation in many parts of the country. The work has passed the experimental stage and has demonstrated not only that game protection can be made self-supporting, but that reasonably accurate estimates are possible as to the returns to be expected in almost any State. Omitting such centers of population as the great cities, it is safe to assume that from 3 to 5 per cent of the total population of the State will purchase licenses if a uniform $1 hunting license is in force. This will create a fund sufficient in almost every State to carry on the work. At least 12 States—Alabama, California, Connecticut, Idaho, Illinois, Michigan, Missouri, Montana, North Carolina, North Dakota, Washington, and Wisconsin—have already reached the point where the work of game protection is self-supporting. Similar results can be accomplished in most of the other States as soon as public sentiment has been awakened sufficiently to demand the necessary legislation. In 1905 the funds for game protection amounted to nearly $1,000,000, of which more than $500,000 was received from fees for hunting licenses, about $350,000 from specified appropriations, and the remainder from receipts from fines and miscellaneous sources.

To what extent game may be developed as a national resource can only be suggested by a few illustrations.

VALUE OF GAME.

The value of game may be direct or indirect. It may yield the State a direct revenue in the form of fees from hunting privileges and leases, and the owner a cash return from its sale for food, hides, trophies, and other products, or, if alive, for purposes of propagation; it may also directly increase the value of land. The principal indirect benefit is from the influx of nonresidents—hunters, photographers, and summer visitors—attracted by its presence, with the resultant employment of guides, boatmen, and camp help, and coincident increase of local business. The permanent financial benefit derived from this source has been thus summarized by Senator W. P. Frye:

> In all times of business depressions and distress, financial panics and consequent unemployment of labor, so seriously affecting the country, the State of Maine has suffered much less than any other State in the American Union, mostly, if not entirely, due to the large amount of money left with us by the fishermen, the summer tourist, and the fall hunter—the seeker after change, rest, and recreation.[a]

REVENUE FROM HUNTING LICENSES.

The modern system of hunting licenses in the United States practically began in 1895, and has been gradually extended until at present residents are required by nearly half of the States, and nonresidents by all but 5, to obtain licenses to hunt game. The price of a resident license is usually $1, while that of a nonresident license varies from $10 to $50. The rapid growth of the license system is shown by the fact that in 1903 resident licenses were required in 13 States, nonresident in 31; in 1905 resident licenses were required in 17 States, nonresident in 36; and in 1907 resident licenses in 21 States and nonresident in 43.

Receipts from these licenses have grown from inconsiderable amounts to large sums, which in several States are amply sufficient to support an efficient game warden force, and in a few to provide a large surplus available for the introduction and propagation of game. Thus in 1907 California collected more than $118,000 from the sale of hunting licenses, and Illinois about $145,905.[b] The returns for 1905, the latest year available, are shown in the table on the following page, which, for purposes of comparison, includes also the figures for 1903.

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[a] Rept. Comm. Inland Fisheries and Game of Maine, for 1902, p. 21.

[b] Total receipts amounted to $191,943.50, from which have been deducted clerks' fees aggregating $46,038.50.

Number of hunting licenses issued and total fees collected in 1903 and 1905.

State.	1903.				1905.			
	Resident.	Nonresident.	Total licenses.	Total fees.	Resident.	Nonresident.	Total licenses.	Total fees.
Arizona	(a)	(a)	(a)	(a)	(a)	[b] 11	11	$110
Colorado	15,184	34	15,218	$15,930	19,364	30	19,394	19,980
Delaware	(a)	315	315	1,027	(a)	213	213	516
Florida	(a)	....	....	....	(a)	607	607	6,070
Idaho	12,370	267	12,637	14,105	15,010	112	15,122	16,050
Illinois	95,000	250	95,250	98,875	161,164	459	161,623	127,988
Indiana	....	....	....	....	13,200	116	13,316	14,996
Iowa	(a)	....	....	....	(a)	....	....	....
Kansas	(a)	(a)	(a)	(a)	42,000	20	42,020	42,300
Kentucky	(a)	....	....	....	(a)	....	....	....
Louisiana	(a)	(a)	(a)	(a)	(a)	....	....	832
Maine	(a)	1,697	1,697	25,465	(a)	2,413	2,413	33,155
Maryland	(a)	26	26	154	278	69	347	805
Michigan	19,061	45	19,106	15,421	14,878	105	14,983	24,942
Minnesota	8,910	333	9,243	14,205	15,861	309	16,170	20,211
Missouri	(a)	(a)	(a)	(a)	47,746	65	47,811	48,721
Montana	(a)	72	72	1,690	30,087	133	30,220	32,062
Nebraska	3,744	84	3,828	4,584	5,202	140	5,342	6,002
New Hampshire	(a)	135	135	1,350	(a)	469	469	4,690
New Jersey	(a)	301	301	3,161	(a)	264	264	2,772
New York	(a)	....	....	....	(a)	48	48	506
North Carolina	(a)	916	916	9,389	(a)	987	987	10,117
North Dakota	11,574	123	11,697	11,756	13,187	96	13,283	12,290
Ohio	(a)	17	17	429	(a)	31	31	473
Oregon	(a)	(a)	(a)	(a)	19,856	138	19,994	21,236
Pennsylvania	(a)	....	....	....	(a)	....	....	....
South Dakota	....	....	....	....	615	371	986	5,278
Tennessee	(a)	40	40	200	(a)	....	....	417
Utah	(a)	30	30	300	(a)	9	9	225
Vermont	(a)	(a)	(a)	(a)	(a)	28	28	420
Virginia	(a)	348	348	3,480	(a)	355	355	3,550
Washington	14,982	(c)	14,982	14,982	26,015	(c)	26,015	26,271
West Virginia	(a)	29	29	464	(a)	21	21	336
Wisconsin	78,164	659	78,823	90,169	73,474	781	74,255	88,019
Wyoming	299	158	457	8,199	2,347	168	2,515	12,140
Total	259,288	5,879	265,167	335,335	500,284	8,568	508,852	584,640

[a] No license in force.

[b] For rate and other details, see Circular 54, Biological Survey, United States Department of Agriculture, 1906, pp. 9, 13.

[c] Nonresident licenses inseparable from resident licenses.

Direct income from licenses.—In the States which have adopted both resident and nonresident licenses the percentage of licensed hunters in 1905 varied from one-fourth of 1 per cent of the population in South Dakota to more than 10 per cent in Montana, but in most of the States it was approximately 3 per cent. In every case in which the proportion was less than 1 per cent the falling off was evidently due to imperfect license laws. The figures in the foregoing table furnish the best basis at present available for estimating the total number of persons hunting in the United States and the amount of revenue obtainable under a uniform hunting-license law. The population of the United States, exclusive of Alaska, Hawaii, and Porto Rico, on June 1, 1905, as estimated by the Census Bureau, was 82,565,005. Three per cent of this number represents approximately the number of persons who hunt. In other words, the total number of persons who hunted in the United States in 1905 may be estimated at 2,500,000 to 3,000,000; hence if a uniform law requiring a $1 resident license had been in force in all the States the total revenue collected from this source would probably have been not less than $3,000,000.

ILLUSTRATIONS OF INCREASE IN VALUE OF LANDS DUE TO PRESENCE OF GAME.

Income from lease of hunting privileges.—In North Carolina shooting on another person's land without permission of the owner is prohibited by the game laws. Under this provision a system of leasing hunting privileges has grown up in certain counties during the last twenty years, especially in the north-central part of the State—in Davidson, Guilford, Forsyth, Moore, and Randolph counties. Owners of adjoining farms agree to permit no hunting on their land except by the lessee or his friends in consideration of the payment of a fixed sum or of all the taxes on the property included.

Guilford County, which may be taken as an illustration, has an area of 680 square miles, a little more than half that of Rhode Island. It contains two important towns, Greensboro and Highpoint. Its population in 1900 was about 40,000. On its farms, which average 100 or 200 acres in extent, wheat, corn, cotton, fruit, and vegetables are the principal crops. In 1904 about 150,000 acres, more than one-third the area of the county, was under lease for private game preserves, each preserve ranging from a few hundred to 12,000 or 15,000 acres. Some leases run for one year; others for five or ten years, with the privilege of renewal. The amounts paid for rental vary from 5 to 10 cents, based on the ordinary tax rate for lands outside the towns, which rate averages about 7 cents per acre. Recently a sum amounting to double the tax rate, or even more, has been paid by some lessees. More than one-third of the total real estate tax of the county, exclusive of that of the towns, is paid in this way by lessees of hunting privileges, who, in some cases, assume also special township school taxes. In other words, by merely keeping trespassers off their lands and uniting with their neighbors in leasing hunting privileges, farmers may be relieved entirely from real estate taxes and may perhaps, in addition, receive each year a substantial amount in cash.

Increase in value of marsh lands due to presence of game.—The marsh lands of California where ducks are abundant have greatly increased in value with the increase in popularity of duck shooting during the last fifteen years. In 1907 more than 100 clubs owned or leased game preserves for shooting purposes. The total area of these preserves is unknown, but it is probably not less than 160,000 acres, or approximately 250 square miles, and the preserves vary in size from a few hundred acres to 46 square miles. The capital invested probably amounts to $5,000,000 and comprises not only the value of the land (in case of ownership by the club), but also leases and such improvements as club houses, farms, and artesian wells, besides boats, arks, decoys, and other hunting paraphernalia. The value of the property may vary from a few hundred dollars, in case of leased grounds, up to a million dollars in case of grounds owned by a club which maintains a club house and develops the hunting facilities of the marsh to the highest degree possible.

Duck preserves in California comprise both fresh and salt water marshes, and may be roughly divided into six groups or districts. The two most important of these are the Suisun marshes on the north side of Suisun Bay, in Solano County, occupied by 12 or 15 clubs, and the marshes in southern California, in Los Angeles and Orange counties, occupied by some 36 clubs. Thirty of the southern California preserves have a combined area of about 40 square miles, and represent an investment approximating $3,000,000.

In 1893 one of the first clubs organized in the State leased 3,000 acres of land in the Suisun marshes for a term of four years at $1,200 per year, or an annual rental of 40 cents per acre. A few years ago a syndicate is said to have purchased 5,000 acres in the same marshes for $100,000, or $20 per acre; and four-fifths of this tract have since been sold or disposed of to members of shooting clubs at prices ranging from $40 to $50 per acre. Similar increases in values have occurred in southern California. In other words, lands suitable for duck preserves, which a few years ago were of little or no value, now command prices of $40 per acre and upward, and the improvements on such property in several instances aggregate thousands of dollars.

Annual kill of big game in the northeastern States.—Moose and deer are the only big game animals which can now be killed east of the Mississippi River. Moose hunting is permitted only in Maine and Minnesota, and deer hunting north of the Mason and Dixon line only in Maine, New Hampshire, Vermont, New York, Pennsylvania, Michigan, Wisconsin, and Minnesota. Statistics of the actual number of moose and deer in any State, or of the annual increase, are not available, and only one State—Vermont—publishes a record of the number annually killed. Statistics of the shipment of big game are collected in Maine and New York, however, and from these, and from other data for Pennsylvania and Michigan, it is possible to estimate the number annually killed in several of the States.

Figures for the decade from 1897 to 1906 are as follows:

Number of moose shipped in Maine (Bangor and Aroostook Railroad).

1897	139	1902	224
1898	202	1903	232
1899	166	1904	222
1900	210	1905	207
1901	259	1906	198

Number of deer killed or shipped in four States.

Year.	Deer killed.		Deer shipped.				
			Maine.		New York (Adirondacks).		
	Vermont.	Michigan (estimated).	Bangor and Aroostook Railroad.	All roads.[a]	Carcasses.	Saddles.	Heads.
1897	103	....	2,940	....	....	....	....
1898	131	....	3,377	....	....	....	....
1899	130	....	3,756	....	....	....	....
1900	123	2,000	3,379	....	1,020	89	95
1901	211	6,000	3,882	6,233	1,062	103	121
1902	403	....	4,495	....	1,354	113	193
1903	753	22,000	3,786	5,853	1,961	145	188
1904	531	7,000	3,558	5,475	1,618	124	152
1905	497	7,000	4,634	6,799	2,196	108	180
1906	634	10,000	3,377	5,494	2,413	108	102

[a] Statistics from the Maine Sportsman.

Explanation of the table.—Statistics of the amount of game killed, as an index to relative abundance, are not always directly comparable, even in adjoining States, for the reason that the three factors of length of season, bag limit, and license fees may conceal or exaggerate differences in the returns from different States, or the fluctuations from year to year in the same State. For example, the deer season in Vermont lasts 6 days, that in Maine 76 days; in Vermont each hunter may kill one deer, while in Maine each may kill two; residents of Maine and Vermont may hunt without a license; in Michigan each must pay $1.50 for the privilege.

Vermont.—As an illustration of the effects of protection and restocking, the statistics of deer killed in Vermont are the most accurate and interesting of any in the United States. Thirty years ago deer in Vermont had been practically exterminated, except in the extreme northeastern corner (in Essex County). About this time a few deer were liberated in the southern part of the State, and these two centers (Essex and Rutland counties) have supplied the stock which has now spread over the State. Deer hunting was prohibited for a number of years, the first open season being that of 1897. The table indicates that from 1897 to 1906 the annual kill increased more than 600 per cent. The actual abundance of the animals must also have greatly increased, for the open season, originally the entire month of October (1897–1898), was shortened after 2 years to the last 10 days in October (1899–1903), and 4 years later to the last 6 days in October (1904–1906). Moreover, since 1904, nonresidents have been required to pay a license fee of $15, and the number of visitors from other States who formerly visited Vermont to hunt deer may have been reduced in consequence of this additional expense.

Michigan.—Fluctuations in the figures for Michigan are due to a combination of causes, artificial as well as natural. In 1900 the season opened with sufficient snow for tracking, and in consequence large numbers of deer were killed. In the following year changes in the game law prohibited sale and reduced the number of deer allowed each hunter to three. These circumstances explain in large measure the reduction of 50 per cent in the number of deer killed. The falling off in 1904 was due to a light snow, and that in 1905 to the same cause, and probably also to the fact that the cost of the resident hunting license was doubled.

Maine.—The only statistics available for a period of years are those for shipments over the Bangor and Aroostook Railroad. But in recent years data are available from other railroads also, and these indicate that the returns from the Bangor and Aroostook Railroad should be considerably augmented to represent the total number of deer shipped in the State. For example, in 1905 and 1906 the figures for the Bangor and Aroostook Railroad are 4,634 and 3,377, respectively, while those for all the roads are 6,799 and 5,494, respectively.

New York.—In New York the deer shipments from the Adirondacks are reported as carcasses, saddles, and heads, but it is impossible to tell exactly how many deer are shipped, for the reason that a saddle and a head may or may not represent parts of the same animal. In addition to the deer killed in the Adirondacks, a few are obtained in other counties, and about 50 or 100 annually on Long Island. In 1895 and 1896 the fish, game, and forest commission reported the total number killed in the State at 4,900 and 5,247, respectively, but in recent reports the annual kill is not estimated. In view of the fact that since 1895 shipments have more than doubled, 5,000 may be accepted as a conservative estimate of the number killed in 1906.

Estimates of annual kill of deer.—Estimates of the number of deer killed in 1906 in Maine, Vermont, Pennsylvania, and Michigan have been made by the state game commissioners. It is probable that the number killed in New York is not less than 5,000, and that in New Hampshire the season's yield is approximately the same as that in Vermont. On this basis the total number of deer killed in these six Northern States is about 35,000, as follows: Maine, 18,000; New Hampshire, 600; Vermont, 634; New York, 5,000; Pennsylvania, 800; Michigan, 10,000. Total, 35,034.

Value of venison.—Assuming the average weight of a dressed deer to be 150 pounds,[a] the total quantity of venison produced in these six States in 1906 was about 5,255,000 pounds. At an average value of 20 cents a pound this would be worth $1,051,000.

FINANCIAL BENEFITS ACCRUING FROM PRESENCE OF HUNTERS AND SUMMER VISITORS.

In 1902 the commissioners of inland fisheries and game in Maine endeavored to ascertain the number of nonresidents who visited the State (exclusive of seaside resorts) for the purpose of fishing, spending vacation, or hunting, and the amount of money left in the State by such visitors. Of sixteen counties in the State, no returns were received from Lincoln and Sagadahoc, and only incomplete returns from Aroostook, Franklin, Penobscot, Piscataquis, Somerset, and Washington. According to the statistics collected, the visitors in 1902 numbered 133,885, and paid for board $1,371,201 and for guides $300,000. Their presence involved the employment of 3,965 persons—1,401 males and 2,564 females. The figures for receipts, wages, and capital invested are as follows:

Receipts, wages, and capital invested on account of summer visitors in Maine, 1902.

Cash received for board of visitors	$1, 371, 201
Wages for male help	153, 541
Wages for female help	114, 398
Value of boats, canoes, and launches	815, 048
Money invested in summer hotels, cottages, and hunting camps	5, 541, 274

Statistics of the amount of money paid for railroad, electric car, and steamboat fares, for team hire, and for other purposes are not available. The commissioners add:

> It is believed that a most conservative estimate would be that these visitors leave at least $100 each, on an average, in the State. Indeed, some of them spend more than $50 a day, and a good many of them spend several thousand dollars each year.

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[a] That these estimates are conservative is shown by the fact that the average weight of dressed deer killed in Vermont in 1905 was 198 pounds, while in New York the heaviest bucks occasionally weigh 265 or rarely 285 pounds. The value of venison varies greatly with the market where it is sold.

It will be seen, therefore, that if they spend on an average $100 each, over $13,000,000 are left by them in Maine each year; or if they spend but $50 each they leave six millions and a half of money with us annually. (Rept. Comm. Inland Fisheries and Game, 1902, pp. 34–35.)

FARMING DEER AND OTHER GAME.

As a result of the growing scarcity of game the supply of venison and game birds is wholly inadequate to the demand, and the time seems to have arrived for the propagation of game on private preserves or game farms.

The raising of venison and game birds for market is as legitimate a business as the growing of beef and mutton, and state laws when prohibitory, as many of them are, should be so modified as to encourage the industry of game breeding. Deer and elk may be raised to advantage in forests and on rough bushy ground unfit for either agriculture or stock raising, while ducks and other waterfowl may be bred on otherwise valueless marshes, so that large areas of waste land may be utilized for profit. An additional advantage is that the business is well adapted to landowners of small means. Besides supplying game for market, breeders of game mammals and birds may find even greater profit in raising them for stocking preserves. For many years to come the demand for this purpose is likely to exceed the supply.

VALUE OF FUR-BEARING ANIMALS.

The United States, with Alaska and outlying islands, forms a large part of what was once the richest fur-producing region in the world. Its present output is still large, but it is obtained with increasing difficulty and the future is very uncertain. Excepting the arid and treeless parts of the West, practically all the territory now included in the United States was inhabited originally by animals bearing valuable pelts. In the Eastern States these animals were speedily reduced in numbers or driven to less accessible regions, and their pursuit as a business soon passed to the Western and Northern States.

With the purchase of Alaska in 1868 the United States became more than ever identified with the fur trade, for in addition to great quantities of less important kinds this great territory produced a majority of the world's supply of fur seal and sea otter skins and a considerable proportion of silver-black fox, three of the most valuable of furs. But even in Alaska the pace set was too rapid, and the natural increase of the animals failed to keep up with it.

Although the ranges of the more important fur-bearing animals have become more and more restricted, and the animals themselves have rapidly diminished in numbers, still the annual volume of trade as expressed in dollars and cents has remained remarkably uniform, even showing a tendency to increase. Thus the exports of raw furs in 1890 amounted to $4,661,934, in 1895 to $3,923,130, in 1905 to $6,599,222, and in 1906 to $8,002,282. For the twenty-five years from 1875 to 1900 the average annual export value of furs was more than $4,000,000, the total for this period, therefore, being over $100,000,000. These figures are explainable only by the fact that many furs have doubled, trebled, and even quadrupled in price; so that, although total receipts do not fluctuate greatly, the number of pelts marketed annually is much smaller than formerly.

As indicating the extent of the annual fur trade in the United States, the following table is given, being an estimate of the number and value of certain of the more important furs produced in the United States during 1900:[a]

Designation.	Number of skins.	Value.
Beaver	8,000	$39,80
Fur seal	24,000	660,00
Mink	578,000	810,60
Muskrat	4,035,000	565,00
Otter	14,600	93,29
Sea otter	330	133,98
Total value		$2,302,18

The accompanying table shows the value of furs exported yearly from the United States since 1890:

Value of furs exported from the United States, 1890–1907.[a]

Year.	Value.	Year.	Value.	Year.	Value.
1890	$4,661,934	1897	$3,284,349	1904	$5,422,954
1891	3,236,705	1898	2,986,970	1905	6,599,222
1892	3,586,330	1899	3,092,846	1906	8,002,282
1893	3,699,579	1900	4,503,968	1907	7,139,221
1894	4,238,690	1901	4,404,448		
1895	3,923,130	1902	5,030,204	Total exports, 1890–1907	$83,794,115
1896	3,800,168	1903	6,181,115		

[a] From Commerce and Navigation, Bureau of Statistics, U. S. Dept. Commerce and Labor.

Average annual value for these eighteen years, $4,655,228.

INCREASED DEMAND FOR AND PRODUCTION OF LOW-GRADE FURS.

That the supply of the better grades of furs is unequal to the present demand is proved not only by the higher prices they bring, but also by the steady increase in the quantity of cheaper furs used and by the additional fact that these cheap furs have gradually brought higher and higher prices, until now they command prices equaling or exceeding those formerly paid for better furs. Very large quantities of cheap furs are manufactured in the United States, in addition to those sold in the London market, but statistics of the home-manufactured product are not available.

The fur of skunks, for example, was practically unnoticed prior to 1850. In 1851 the Hudson Bay Company offered 1,453 skunk skins for sale, and for twenty years the annual number sold was scarcely more than 10,000. In 1891 the number had increased to upward of 400,000, and the increase, both in number and price, has continued to the present time, the number reaching 1,368,475 skins in 1907, as shown by the following table:

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[a] From Ann. Rept. U. S. Comm. Fisheries, 1902, p. 287.

Skunk fur sold in London market.[a]

Year.	Number of skins.	Advance in price.	Decline in price.
		Per cent.	*Per cent.*
1891	422,398	([b])	
1892	635,800		10
1893	575,472	11½	
1894	739,228		20
1895	542,885	([c])	
1896	796,750		32½
1897	872,323	([b])	
1898	482,130	22½	
1899	426,610	60	
1900	695,686	16	
1901	696,961		12
1902	973,605	25	
1903	987,550	5	
1904	911,923		12½
1905	952,549	25	
1906	1,225,582		
1907	1,368,475		

[a] Compiled from London sales. [b] Stationary. [c] No report.

Muskrat fur has been in use much longer than skunk, but for years was little valued. Now it has been computed that about 5,000,000 animals are killed annually. The total product of this fur in the United States is now worth at least $1,000,000 annually.

Muskrat fur sold in London market.[a]

Year.	Number of skins.	Advance in price.	Decline in price.
		Per cent.	*Per cent.*
1891	1,832,965	10	
1892	2,182,785		40
1893	3,144,236	5	
1894	3,662,076		([b])
1895	2,565,157		15
1896	3,028,083	40	
1897	2,341,283	10	
1898	2,674,651	([c])	
1899	1,763,237		10
1900	3,508,352		([c])
1901	3,408,447		10
1902	4,733,479	([c])	
1903	4,321,459	35–70	
1904	4,477,937	([d])	
1905	5,227,461		15
1906	4,903,080		
1907	3,391,494		

[a] Compiled from London sales. [b] Slight. [c] Stationary. [d] About stationary.

Increased prices have given greater incentive to the pursuit of fur-bearing animals, so that the work of extermination begun decades ago has progressed in recent years with greater and greater rapidity. The most conspicuous examples of rapid decrease are those of the sea otter and the fur seal. From 1873 to 1885 the annual catch of sea otters in Alaskan waters was from 3,000 to 4,000 skins. Estimating these conservatively as worth $300 each, the total yearly value was about $1,000,000. In 1895 the catch had dropped to 887, and in 1905 to 320, a decrease of approximately 90 per cent in twenty years. The Pribilof fur seals, which once yielded millions of dollars, have decreased enormously during the past twenty years. Thus the average yearly catch on the islands from 1868 to 1889, inclusive, was

104,834, while for the years 1904–1906 it averaged 13,249. In other words, an important source of revenue in a region otherwise unproductive is gradually being destroyed.

Comparison of the value of the total shipment of furs from Alaska for the past five years, 1903–1907, with the figures for corresponding previous periods, emphasizes the fact that the actual number of furs formerly exported annually was so much greater than now that even at the comparatively small prices then prevailing the value of the exports for each of the two periods from 1881 to 1885, inclusive, and from 1886 to 1890, inclusive, was practically five times as great as during the past five years.

Shipments of furs from Alaska.

Year.	To foreign countries.	To United States.	Total shipments.
1903	$6,550	$423,606	$430,156
1904	21,099	449,497	470,596
1905	7,331	494,764	501,095
1906	12,466	494,911	507,377
1907	1,114	646,652	647,766
Total shipments for past five years			$2,556,990
Total shipments 1881–1890 [a]			23,725,783
Total shipments 1871–1880 [a]			21,049,940
Total shipments 1868–1870 [a]			3,743,206

[a] Population and resources of Alaska, Eleventh Census (1890), p. 215, 1893.

DECREASE AND REMEDIES.

Accurate figures showing the rate of decrease of the wide ranging smaller fur-bearing animals are not obtainable, but most of these animals are everywhere greatly reduced in numbers, and throughout a large part of their original range are practically extinct. The beaver, for example, which was formerly abundant over three-fourths of North America, is now extinct in more than half of this area, and over the remainder occurs only in relatively small numbers. In 1870 the number of beaver skins exported from North America was approximately 225,000; in 1890 it had diminished to 82,000. Other fur bearers, as foxes, martens, fishers, and land otters, are similarly decreasing, as shown by the number of skins exported.

Throughout the length and breadth of coniferous forests of the Rocky Mountains from Montana to New Mexico, and of the Sierra-Cascade Range from the State of Washington to southern California, fur-bearing animals were formerly so abundant as to form the principal source of revenue to the early explorers and settlers. Now they are so scarce as to be unimportant. The cause of this great decrease over more than 150,000,000 acres of our public domain is not so much overtrapping as overgrazing. Overgrazing by sheep has converted many thousands of miles of brushy slopes and mountain meadows into barren deserts, destroying the cover which sheltered the hordes of small mammals and birds on which the fur bearers subsist.

The practical extinction of fur-bearing animals in areas suitable for settlement and for the development of agriculture or manufacturing is inevitable, but in areas not needed for the development of industries there is no necessity for their utter depletion. The greater part of the vast territory of Alaska and thousands of square miles of national forests, national parks, and other wild forest lands in the United States when not injured by overgrazing offer ideal conditions for the continued existence of these species. These animals, if fostered in such regions, will not only prove a valuable asset in themselves but in many localities will add to the value of the forest, for most of them prey upon the insects and gnawing animals which are constantly at work injuring trees and devouring seeds on which the future life of the forest depends.

The remedy seems to lie in the prevention of overgrazing and in the enactment of laws limiting the open season for trapping. Many of the States have already realized the necessity for such legislation and have acted accordingly. It remains only for other States and the National Government to follow their example in order to provide for the preservation and utilization of an important natural resource which, at no cost for maintenance, may be made to yield a substantial annual revenue.

A good example of such protective laws is the one passed by the State of Michigan in 1897, extracts of which are here given.

AN ACT For the protection of certain fur-bearing animals.

[Act 86, P. A. 1897.]

The people of the State of Michigan enact:

(518) Paragraph 5825. SECTION 1. It shall not be lawful for any person or persons to trap, catch, kill, or destroy, or attempt to trap, catch, kill, or destroy, by any means whatsoever, any beaver in this State until the thirty-first day of December, nineteen hundred ten.[a]

(519) Paragraph 5826. SEC. 2. No person shall hunt, trap, catch, kill, or destroy, or attempt to hunt, trap, catch, kill, or destroy, within this State, by any means whatsoever, any otter, fisher, or marten, from the first day of May in each year to the fifteenth day of November following thereafter.

(520) Paragraph 5827. SEC. 3. It shall be the duty of every person having knowledge or information that acts amounting to a violation of this act have been committed to at once report the same to the State game and fish warden, or to the deputy game and fish warden residing in or having supervision over the county wherein the alleged violation was committed, or to the prosecuting attorney of such county, whose duty it shall be to forthwith prosecute the offender.

(521) Paragraph 5828. SEC. 4. Any person who shall be found guilty of a violation of any provisions contained in the foregoing act shall, upon conviction thereof, be deemed guilty of a misdemeanor, and be punished by a fine of not less than ten dollars, nor more than fifty dollars, and the costs of prosecution, or imprisonment in the county jail not to exceed ninety days, or both such fine and imprisonment, in the discretion of the court.

AN ACT to protect mink, raccoon, skunk, and muskrats during the months of September and October in each year, and to provide a penalty for the violation thereof.

[Act 201, P. A. 1899.]

The people of the State of Michigan enact:

(522) SECTION 1. That it shall not be lawful for any person or persons to trap, hunt, shoot, or kill any mink, raccoon, skunk, or muskrat in this State during the months of September and October in each year; (*a*) except it be on his own premises, and such person can prove that the said animal was damaging him: *Provided, however*, That this act shall not be construed so as to repeal act number twenty-seven of the session of eighteen hundred ninety-seven; *Provided further*, That nothing in this act shall prevent water-power owners from

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[a] Am. 1905, act 204.

killing or destroying muskrats within one-half mile of any water power in this State: *And provided also*, That nothing in this act shall be construed to prevent owners of dykes from killing or destroying muskrats on or along such dykes when damaging such dykes.

(523) SEC. 2. Any person who shall be found guilty of violating any of the provisions of this act shall, upon conviction thereof, be deemed guilty of a misdemeanor, and shall be liable to a fine of not more than one dollar and costs of prosecution for each and every animal killed.

ECONOMIC RELATIONS OF BIRDS.

So important are birds as conservators of the forest and as protectors of farm crops that neither forestry nor agriculture could be successfully practiced without their aid. As year by year the value of farm and orchard products increases, so the value of birds as conservators of the farmers' interests increases. The need of adequate legislation in favor of insectivorous birds was never so great as now, and it is probable that in the future protective laws will be still more important. Insectivorous birds spend their lives in the pursuit of insects, vast numbers of which are required for their support. The seed-eating birds attack noxious weeds at the most critical stage of their existence, during and after seeding, and as seeds constitute for these birds the staff of life the quantity they destroy is incalculable. No labor-saving machine has ever been devised that equals the value to the farmer of the seed-eating birds. The predatory birds, mainly hawks and owls, render an even greater service, keeping down the hordes of mice, gophers, ground squirrels, and other vermin that destroy crops. It is not too much to say that such outbreaks as the recent field-mouse plague in Nevada would never occur were it not that our predatory animals have been so greatly reduced by ruthless killing that they are no longer able to prevent the increase of these pests.

A good illustration of the costliness of popular misconceptions as to the economic status of some of our common birds and mammals may be found in the so-called "scalp act" of Pennsylvania, passed in 1885. This act provided a bounty of 50 cents each on hawks, owls, weasels, and minks killed within the state limits and a fee of 20 cents to the notary or justice taking the affidavit. As a result about $90,000 was paid in bounties during the year and a half subsequent to the passage of the act. This amount represents the destruction of at least 128,571 of the above-mentioned animals, most of which were hawks and owls. Estimating that 5,000 chickens are annually killed in Pennsylvania by hawks and owls, and that their value is 25 cents each (a liberal estimate in view of the fact that a large proportion of them are killed when very young), the total loss of poultry in a year and a half would be about $1,875. It thus appears that $90,000 were paid by the State of Pennsylvania to save its farmers a loss of less than $2,000. But this estimate by no means represents the actual loss to the farmer and taxpayer of the State. It is safe to say that every hawk and owl yearly destroys at least 1,000 mice, or their equivalent in insects, and that each mouse or its equivalent so destroyed would cause the farmer a loss of 2 cents per annum. Thus the lowest possible estimate of value to the farmer of each hawk and owl would be $20 a year. The actual loss to the State, therefore, by the destruction of 128,571 of its benefactors in a year and a half was about $3,850,000. Even these figures, enormous as they are, do not represent the entire loss to the State, since the destruction of such a vast number of predaceous birds and mammals is sure to be followed by a corresponding increase in the number of mice and insects, their natural prey, and years must elapse before the balance of nature thus destroyed is restored.

LOSSES FROM CARNIVOROUS MAMMALS.

Wolves are still numerous in parts of Wyoming, Montana, the Dakotas, Nebraska, Kansas, Colorado, New Mexico, Arkansas, Oklahoma, Missouri, Michigan, Wisconsin, and Minnesota, and yearly destroy great numbers of cattle and horses. Coyotes are numerous over a still larger area and destroy vast numbers of sheep, while cougars, or mountain lions, in certain parts of the West kill annually so many colts that they must be reckoned with as an economic factor of considerable importance.

Bounties have had little effect in exterminating predatory animals, or even in permanently reducing their numbers. Thus, in Wyoming, where liberal bounties for wolves and coyotes have been paid for the past twelve years, both animals are still numerous. This is shown by the following table:

Bounty records for twelve years in Wyoming.

Year.	Number of wolves on which bounty was paid.	Bounty per wolf.	Total amount paid in bounties.
1895	1,699	$3	$5,097
1896	3,365	3	10,095
1897	897	4	3,588
1898[a]	....	....	....
1899 and 1900[b]	4,908	3	14,724
1901 and 1902[b]	4,480	3	13,440
1903 and 1904[b]	2,256	5	11,280
1905 and 1906[b]	3,214	3	9,642
Total for 11 years	20,819	....	67,866

[a] Species not reported separately; $14,160.25 paid on wolves, coyotes, and mountain lions.
[b] Biennial reports not separated by years.

In 1906 Mr. Victor Culberson, president and manager of the G. O. S. Cattle Company, on the Gila Forest Reserve, Grant County, N. Mex., estimated the loss of cattle killed by wolves to be 10 per cent of the herd. This loss was sustained under a bounty system of $20 per head for wolves, as shown in the following table:

Bounty records for four years in Grant County, N. Mex.

Year.	Number of wolves on which bounty was paid.	Bounty per wolf.	Total amount paid in bounties.
1902	11	$20	$220
1903	33	20	660
1904	54	20	1,080
1905	29	20	580
Total for 4 years	127	....	2,540

Although no exact figures are available, the following estimate is probably not far from the truth and is at least safely conservative:

A prominent stockman of Wyoming estimates the losses from predatory animals in that State at $1,000,000 a year, or about 3 per cent of the total value of the stock of the State. Assuming that the percentage of loss in other States infested by wolves, coyotes, and cougars ranges from one-tenth of 1 per cent of the value of the stock to 2 per cent (the estimate being made from known conditions), the annual losses aggregate as follows:

Range cattle	$5, 889, 000	
Horses and mules	1, 636, 000	
Sheep	4, 152, 000	
Hogs	584, 000	
Goats	83, 000	
		$12, 344, 000
Poultry (by coyotes, wildcats, foxes, mink, weasels, etc)		1, 500, 000
Total		13, 844, 000

This estimate does not include the game animals destroyed by carnivorous mammals, the value of which aggregate several million dollars yearly.

Thus the combined losses of stock and wild game from predatory mammals, especially from wolves and coyotes, amount to many millions annually. The extermination of these animals under present conditions is not possible, nor indeed is it necessary, since by energetic and concerted action throughout the infested States their numbers can be permanently reduced and the losses kept down to a minimum, with or without the offering of bounties. It is safe to say that by the methods recommended by the Biological Survey, and actually put into effective operation in and adjacent to the national forests by the Forest Service, fully half this loss, about $7,000,000, may be saved each year.

LOSSES FROM RODENTS.

Prairie dogs.—Prairie dogs infest most of the open plains country of the United States from near the Canadian boundary south into Mexico, and from a little east of the one hundredth meridian westerly to the foot-hills of the Rocky Mountains, and also a considerable part of the plateau country still farther west. Their colonies—"dog towns," as they are commonly called—vary in extent from a few acres to thousands of square miles and are inhabited by thousands and in some cases by millions of animals. Colonies 20 to 30 miles in length are not rare, and in Texas one is known which measures 250 miles one way by 100 to 150 the other, covering an area of about 25,000 square miles. The number of holes in use in each acre varies from a few to upward of a hundred, and probably averages at least 25. In winter and early spring the usual number in each hole is two (a pair), while after the birth of the young the number is at least quadrupled, and then decreases with the advance of the season, as the young are killed by their enemies. It is certainly a conservative estimate to assume the average number of animals per acre to be 25. On this assumption, the number of prairie dogs in the great Texas colony must be at least 400,000,000.

It is estimated that 32 prairie dogs consume as much grass as 1 sheep, and 256 prairie dogs as much as 1 cow. On this basis the grass annually eaten by these pests in the great Texas colony would support 1,562,500 head of cattle. It is no wonder, therefore, that the annual loss from prairie dogs is said to range from 50 to 75 per cent of the producing capacity of the land and to aggregate millions of dollars. The annual rental value of range land for grazing purposes is from 8 to 15 cents per acre. At an average damage of 5 cents per acre the loss amounts to $1,500,000 per year. But grass is by no means the only crop injured by prairie dogs, for they are extremely destructive also to grain and other products of the soil. The annual loss to farmers from this source probably reaches $1,000,000, making the total annual loss about $2,500,000.

In the open grazing regions where natural conditions prevail prairie dogs usually increase slowly and do not extend their range rapidly. But the settlement of an infested district usually results in a large increase of the food supply and is followed by a rapid extension of range and great increase in the numbers of the pests. Even in areas where they were not particularly numerous previous to the arrival of the farmers, they soon become so abundant that without some cheap and successful method of destroying them profitable agriculture becomes impossible.

In the State of Kansas in 1901, 2,500,000 acres were occupied by prairie-dog colonies. Here as elsewhere the animals damaged the pasture fully 50 per cent, the actual loss amounting to half the rental value of the land, which ranged from 4 to 12 cents per acre. The annual loss to the cattle owners of the State was estimated at $100,000, and the loss to crop producers at nearly as much more. In 1902 the State took the matter in hand and organized a campaign of extermination. The State furnished poison at cost of manufacture, and the work was done under township supervision, the funds being raised by taxation. The total expense, distributed over five years (1902–1906), was about $85,000, or slightly more than 4 cents per acre, as a result of which the prairie dogs were destroyed on at least 2,000,000 acres of infested land.

The good effects on the pasturage were apparent the first year after the prairie-dog town was destroyed, especially where the mounds were leveled. New grass came in on the bare spots and grew luxuriantly. Cattle preferred the parts of the pasture where the "dog town" had been located; whereas when the dogs were present these had been carefully avoided. The sustaining capacity of the land was greater than ever before and a large increase was noted in the selling value. The annual saving to the people of western Kansas is fully double the total cost of the entire work of extermination. It is obvious, therefore, that by the systematic use of well-tried methods over the country now suffering large annual losses from prairie dogs the total of these losses may be easily reduced by at least $1,000,000.

Ground squirrels.—Ground squirrels occur almost everywhere from the Mississippi Valley to the Pacific Ocean, and one species ranges east to Indiana and southern Michigan. The extent of the area they inhabit collectively is about 1,900,000 square miles, or 1,216,000,000 acres. The more destructive species occupy about 825,000 square miles, or 528,000,000 acres, of which 115,000,000 acres are in crops and 413,000,000 acres in range and waste lands.

Ground squirrels rank among the most destructive of North American mammals, causing an annual loss to grain and other crops of about $10,000,000, fully half of which may be saved by the general adoption of methods of poisoning and trapping recommended by the Biological Survey.

The present annual losses in the infested States of the Missouri-Mississippi valley vary from less than 1 per cent to 2 per cent of the grain crop; but in the Sandhills region of western Nebraska and Kansas the loss is so great that in places it is hardly worth while to plant. From Montana and Colorado westward to Washington, Oregon, and California the loss amounts to from 2 to 10 per cent of the value of the grain crop.

Besides the injury to cultivated crops, ground squirrels where abundant do considerable damage to grazing lands by eating the grass and covering it with mounds. This loss is not included in the above estimate of $10,000,000.

The economy of destroying ground squirrels on agricultural lands is not open to question. By the use of poisoned grain and poisoned alfalfa the smaller species are easily killed, at an average cost, including necessary labor, of about 4 cents per acre, or $25 a section. The wheat or barley crop on a section of land in the State of Washington, where the Townsend ground squirrel is abundant, is worth on an average $15 an acre, or $9,600 a section. In badly infested areas the squirrels destroy 10 per cent of the crop, worth $960. By the expenditure of $25 the owner of the section can save $935 the first year and $960 annually for the three or four succeeding years, or until the animals again become abundant.

The cost of destroying the larger species is considerably greater, but, allowing for the difference in expense, the saving on grain would scarcely fall below $800 a section.

On range lands, however, the case is very different, and the economy of destroying the squirrels is doubtful. It has been estimated that 500 of the smaller ground squirrels consume as much grass as a horse or cow. Allowing 10 squirrels to the acre, their destruction would permit the pasturage of an additional horse or cow to each 50 acres. The detriment to the range by squirrels, when abundant, is about 20 per cent of the sustaining capacity. Placing the average rental of the range at 5 cents an acre for the season, the loss amounts to 1 cent an acre. As the destruction of squirrels costs 4 cents an acre, it would require four seasons of freedom from the pests to recover the outlay. Unless, therefore, the work were undertaken on a large scale, by cooperation, so as to secure lasting results, the investment would not pay. However, since range and waste lands are the source from which cultivated fields are restocked with rodent pests, it would undoubtedly pay to destroy the squirrels on ranges adjacent to cultivated crops.

Pocket gophers.—Pocket gophers are distributed over about 1,800,000 square miles of territory in the United States, chiefly from the eastern part of the Mississippi Valley westward. Of this area about one-tenth is in farm crops, from which are derived returns of about $1,500,000,000 yearly. It is estimated that the losses caused by pocket gophers amount to $12,625,000 a year, as follows:

Loss on alfalfa	$4,000,000
Loss on native hay	2,500,000
Loss on clover and tame grasses	3,000,000
Loss on orchard and other trees	1,750,000
Loss on gardens and crops not included above	575,000
Damage to machinery and embankments	800,000
Total loss	12,625,000

Permanent crops, rather than annual ones, are most subject to injury from gophers, and the damage to corn and small grains is comparatively slight. Gophers devour potatoes, sweet potatoes, melons and cotton, but the chief damage they do is to the hay crop and fruit trees. Their favorite food is alfalfa and clover, which they destroy in two ways—by devouring and by burying. The mounds of earth thrown up in meadows cause heavy losses by covering up the grass and preventing close mowing. Where gopher mounds are abundant, from 10 to 20 per cent of the hay is lost.

The alfalfa growers of the Middle West outside of irrigation districts are the most serious losers from pocket gophers. Statistics of the acreage in alfalfa in most of the States are lacking, but two States, Kansas and Nebraska, will serve for illustration. In 1907 Nebraska had 455,792 acres of alfalfa, producing 1,450,759 tons of hay, which at $5 a ton was worth $7,253,795; Kansas had 743,050 acres of alfalfa, which at the same yield and price was worth $11,800,000. It is estimated that in Kansas pocket gophers compelled farmers to leave 10 per cent of their crop on the ground, and conditions in Nebraska were about the same. It is safe to conclude, therefore, that the loss from gophers in these two States in 1907 amounted to at least $2,000,000.

Throughout the greater part of the upper Mississippi Valley and the whole of the Missouri Valley clover, timothy, and native meadows are infested with gophers, whose mounds cause an average loss of 4 per cent of the hay crop, or a total of over $5,000,000 yearly.

The cost of destroying pocket gophers by poisons is not great. A 40-acre field of clover or alfalfa can be cleared of them at an expenditure of less than $5. Trapping is an excellent though slower method, requiring less outlay aside from labor. The feasibility of destroying gophers has been repeatedly proved, but cooperation over large areas is necessary to secure permanent results.

Field mice.—Short-tailed field mice are generally distributed throughout the grassy and mountainous parts of the United States. Under normal conditions they are among the commonest of rodents and cause losses to agricultural crops and fruit trees exceeding $3,000,000 annually.

In the Old World mouse plagues, differing in intensity, have often occurred and have resulted in widespread destruction. The most recent irruption was in France in 1904, where a considerable part of the loss of $40,000,000 attributed to rats and field mice was due to the latter animals. Until recently no plagues of similar severity have occurred in the United States, but in 1907 field mice increased enormously in various parts of the great basin region, especially in Humboldt Valley, Nevada, where over a considerable area they reached a total of 8,000 to 12,000 per acre. As a consequence 15,000 acres of alfalfa out of the 20,000 in the valley were a total loss, so that the fields had to be plowed and resown. The loss of hay, pasturage, root crops, trees, and the wheat crop for 1908, and the cost of replanting the alfalfa fields amounted to about $20 per acre, or a total for the valley of $300,000.

When the numerous irrigation schemes now on foot are completed, a very large additional acreage will be placed under alfalfa, and unless due precautions are taken a repetition of the Nevada mouse plague is almost certain, since extensive fields of alfalfa, offering the mice shelter as well as sustenance, furnish ideal conditions for their excessive multiplication.

Field experiments by the Biological Survey show that meadow mice are among the easiest mammals to control by poisoning. Under the most favorable conditions two or three years are necessary for them to increase to an actual plague, and during this time they can be effectually destroyed at a cost varying from 10 to 20 cents per acre, according to the degree of infestation; while 40 cents per acre is estimated to be the average cost of destruction after they have become a plague. Thus from a purely economic standpoint it is much cheaper to attack them whenever they show an increase than to wait until they have become excessively abundant. On alfalfa lands yielding gross returns of $50 per acre, the damage done by field mice under normal conditions of abundance amounts to $1 to $2 per acre. Almost the whole of this loss can be prevented at a cost of from 10 to 20 cents per acre, thus saving annually from 90 cents to $1.80 per acre.

Even this expenditure, small as it is, would be unnecessary providing due regard had been paid to the protection of such birds as hawks, owls, gulls, and herons, and of such mammals as foxes, coyotes, badgers, weasels, and skunks—nature's own agents in checking the abnormal increase of small rodents. The Nevada outbreak of mice was the signal for the assembling of mouse-eating birds and mammals in numbers quite sufficient, after the mice had been reduced to something like their normal number, not only to hold them in check but to reduce their numbers far below the normal. It is practically certain that the Nevada plague would never have occurred had not predaceous birds and mammals been so reduced as to be quite inadequate for the service they are always eager to perform. Predatory birds and the smaller predatory mammals are an important part of the national assets, and can not be wantonly destroyed without incurring serious consequences.

House rats and mice.—The most destructive mammalian pests in the United States are the European house rats and mice. They were introduced into America so long ago that they are thoroughly acclimatized and range over nearly the whole cultivated parts of our territory, though much more abundant and destructive in towns and cities than in the country.

Every rat in the course of a year destroys property probably worth from 50 cents to a dollar. From investigations in Washington and Baltimore during the past year it is estimated that the annual losses from rats and mice to merchants and manufacturers in cities having a population of 100,000 or more, amount to $20,000,000. The losses from the destruction of grain, poultry, eggs, and other produce on farms, in villages, and in private residences throughout the country amount to a still larger sum. Injury to buildings, furniture, and fixtures, and the cost of fighting the pest by traps, poisons, dogs, cats, ferrets, and professional rat catchers add materially to the above totals. In the absence of accurate statistics for the United States, estimates of the damage done in other countries are of interest. In Denmark the annual loss from rats is put at $3,000,000; in Great Britain from $25,000,000 to $50,000,000, and in France, in 1904, the loss from rats and field mice was estimated at $40,000,000. These figures are suggestive, in view of the fact that the United States, not including Alaska, has 35 times the area of Great Britain, 15 times the area of France, and 200 times that of Denmark.

The importance of killing rats is greatly increased by the fact that these animals are known to be carriers of vermin and disseminators of bubonic plague and other diseases. In Athens, Odessa, Oporto, Glasgow, and other European cities, and recently in San Francisco, Cal., rats have been sufficiently reduced in number to permit eradication of the plague. In San Francisco and its immediate vicinity, between May, 1907, and February, 1908, 77 deaths from plague occurred, and in the plague-prevention work carried on under supervision of the United States Marine-Hospital Service during the year beginning September 25, 1907, more than 300,000 rats have been captured, and it is estimated that nearly twice as many have been killed by poison.

Present methods of destroying rats are imperfect, and the expense is much greater than it should be. But even the crude methods of the past have saved a substantial amount to the country, and by cooperation and persistence the present improved means of destruction can be made to yield far better results than have yet been attained.

The amount spent in the United States in destroying rats is not known. In Stockholm, Sweden, from 1901–1906, inclusive, 639,515 rats were killed by the municipality at an expense in premiums of $8,570, or about 1⅓ cents per rat. Adding the expense of administration, the actual cost was less than 2 cents per rat. In the United States—as, for instance, in San Francisco—an extensive campaign against rats costs much more, yet it pays financially. But rats are such a menace to the public health that apart from pecuniary considerations they should be destroyed as completely as possible, and the war against them must be continuous to effect a permanent reduction in their numbers.

ESTIMATES OF LOSSES FROM RODENTS.

As in the case of carnivorous mammals, the following estimates are based on damages done in certain areas:

I.—*Losses due to European rats and house mice (including the brown rat, the house mouse, and the roof rat).*

Damage to grains while growing, in shock, stack, bin, crib, etc., up to December 1 each year (1 per cent of value)	$21,079,000
Damage to grains kept on the farm after December 1 for feed, seed, increase of price, etc. (1 per cent)	11,692,500
Damage to grains held in elevators, mills, warehouses, and in transportation on cars, ships, etc. (2½ per cent)	4,282,500
Damage to grain fed (largely in cities) to horses, hogs, poultry, etc., and entirely outside of farms and ranches	8,763,000
Damage to merchandise other than grains—dry goods, furs, meats, vegetables in stores and markets	10,000,000

Loss on young poultry, eggs, marketed (1 per cent of value, census of 1900)		$4,100,000
Fire losses due to rats and mice (one-fifteenth of $15,000,000)[a]		1,000,000
Total loss from European rats and house mice		$55,917,000

II.—Losses due to other rodents.

1. Pocket gophers:		
Damage to alfalfa	$4,000,000	
Damage to native hay	2,500,000	
Damage to clover and tame grass	3,000,000	
Damage to orchard and other trees	1,750,000	
Damage to gardens and crops not included above	575,000	
Damage to mowing machinery	800,000	
		$12,625,000
2. Ground squirrels (*citellus*), annual loss		10,000,000
3. Rabbits:		
Loss to nurseries	$1,200,000	
Loss to orchards	3,600,000	
Loss to forests, gardens, melons, etc	800,000	
Loss to pastures, stacks	400,000	
		6,000,000
4. Prairie dogs (*Cynomys*):		
Damage to pastures	1,500,000	
Damage to grain, forage, and other crops	1,000,000	
		2,500,000
5. Meadow mice:		
Damage to trees	1,800,000	
Damage to grain, alfalfa, hay, etc	1,250,000	
Damage to melons, gardens, etc	250,000	
		3,300,000
6. Woodchucks (damage to clover and hay and to haying machinery)		800,000
7. Cotton rats (*Sigmodon*)		800,000
8. Muskrats (damage to canals, embankments, etc.)		700,000
9. Other native rodents (wood rats, kangaroo rats, white-footed mice, and others)		1,250,000
Annual losses from native rodents		$37,975,000
Annual losses from European rats and mice		55,917,000
Total annual losses from rodents		$93,892,000
Annual cost of fighting rodent pests (traps, poisons, fumigators, bounties, labor)		3,000,000
Total		$96,892,000

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[a] The underwriters place the losses due to defective wiring for electric lighting at $15,000,000 per annum, a large part of which they attribute to gnawing of the wires by rats and mice.

LOSSES TO LIVE STOCK BY DISEASE.

By V. H. Olmsted,
Chief of Bureau of Statistics, U. S. Department of Agriculture.

In compliance with the request of the commission, the following statements are submitted of the estimated percentages of loss to live stock from disease for a number of years, each year ending March 31. The figures have been reduced to five-year and three-year averages.

Estimated percentage of loss from disease for the year ending

HORSES.

State or Territory.	1908.	1907.	1906.	Three-year average.	1905.	1904.	1903.	1902.	1901.	Five-year average.	190
Maine	1.7	1.2	1.0	1.3	1.7	1.1	2.2	1.5	1.6	1.6	1.3
New Hampshire	1.4	1.6	1.6	1.5	1.5	1.4	2.0	2.1	1.9	1.8	1.5
Vermont	1.3	1.5	1.4	1.4	1.5	1.4	1.4	1.8	1.8	1.6	1.5
Massachusetts	2.2	1.5	1.3	1.7	1.6	1.6	1.8	1.8	1.1	1.6	1.6
Rhode Island	2.5	1.2	1.1	1.6	1.2	2.3	2.4	2.0	1.8	1.9	1.4
Connecticut	2.0	1.8	1.8	1.9	2.8	2.2	3.6	1.9	1.8	2.5	1.8
New York	2.2	1.8	1.5	1.8	1.7	1.8	1.7	1.9	2.1	1.8	2.1
New Jersey	1.7	1.5	1.7	1.6	1.7	2.3	1.9	1.7	2.1	1.9	2.0
Pennsylvania	1.7	1.7	1.5	1.6	1.8	1.9	2.3	1.7	1.5	1.8	1.7
Delaware	1.7	1.9	1.8	1.8	3.7	1.8	2.5	2.9	3.8	2.9	2.8
Maryland	1.4	1.5	1.9	1.6	1.7	1.7	2.1	2.3	2.6	2.1	1.8
Virginia	1.8	1.7	1.6	1.7	1.8	2.0	1.7	2.0	1.8	1.9	2.1
West Virginia	1.1	1.6	1.5	1.4	1.7	1.7	1.4	1.4	1.6	1.6	1.8
North Carolina	2.0	1.9	1.8	1.9	2.0	2.2	2.0	2.2	1.7	2.0	2.0
South Carolina	2.2	2.0	2.0	2.1	3.0	3.6	3.0	3.1	2.5	3.0	2.8
Georgia	2.0	2.0	2.1	2.0	2.5	3.5	3.3	3.8	2.3	3.1	3.3
Florida	3.0	3.1	3.0	3.0	2.9	4.3	2.9	3.2	3.5	3.4	4.2
Ohio	1.4	1.6	1.8	1.6	1.3	1.5	1.2	1.4	1.4	1.3	1.2
Indiana	1.8	1.7	1.5	1.7	1.5	1.9	1.7	1.7	1.5	1.7	1.7
Illinois	1.4	1.4	1.6	1.5	1.6	1.5	2.0	1.8	1.7	1.7	2.1
Michigan	1.6	1.8	1.6	1.7	1.6	1.8	1.6	1.9	1.7	1.7	1.5
Wisconsin	1.4	1.8	1.5	1.6	1.7	1.7	1.4	1.7	1.4	1.6	1.6
Minnesota	1.8	2.0	1.7	1.8	2.0	2.0	2.0	2.2	2.4	2.1	1.8
Iowa	1.7	1.8	1.3	1.6	1.4	1.5	1.6	1.6	1.7	1.6	1.2
Missouri	1.3	1.5	1.6	1.5	1.7	1.8	2.0	2.4	1.5	1.9	1.7
North Dakota	1.9	2.2	1.5	1.9	1.4	2.4	2.1	1.7	1.8	1.9	1.3
South Dakota	1.5	1.8	1.6	1.6	1.4	1.6	1.6	1.4	1.4	1.5	1.3
Nebraska	1.8	1.9	1.8	1.8	1.5	1.6	2.3	2.7	1.7	2.0	1.5
Kansas	1.1	1.3	1.5	1.3	1.2	1.3	1.2	1.5	1.3	1.3	1.3
Kentucky	1.9	2.0	2.0	2.0	2.0	1.8	2.1	2.6	2.0	2.1	2.3
Tennessee	1.8	2.0	1.8	1.9	[a]2.0	1.9	2.9	2.7	2.1	2.3	3.1
Alabama	2.0	2.3	2.5	2.3	2.4	2.5	3.3	2.8	2.0	2.8	2.6
Mississippi	2.5	2.5	2.8	2.6	2.4	2.8	2.7	3.1	2.7	2.7	2.6
Louisiana	3.2	2.4	3.5	3.0	3.5	3.1	3.3	2.7	3.0	3.1	2.9
Texas	1.9	2.7	2.3	2.3	2.7	2.6	2.1	2.9	2.1	2.5	2.2
Indian Territory	......	3.3	2.8	[b]3.0	2.0	3.0	3.4	1.6	2.6	2.5	......
Oklahoma	2.0	2.8	1.9	2.2	1.9	1.7	1.3	2.0	2.3	1.8	1.6
Arkansas	2.4	2.2	2.6	2.4	2.1	2.8	2.9	2.6	2.3	2.5	2.3
Montana	1.5	2.2	2.0	1.9	1.6	1.7	1.4	1.4	1.6	1.5	1.8
Wyoming	1.3	2.3	1.4	1.7	3.0	1.8	2.6	2.3	1.2	2.2	1.4
Colorado	1.4	2.3	2.2	2.0	1.9	1.9	2.4	1.9	1.6	1.9	1.7
New Mexico	2.5	3.1	2.5	2.7	3.6	2.7	4.5	2.1	3.1	3.2	1.7
Arizona	1.5	2.8	4.0	2.8	1.7	10.3	3.0	1.6	3.0	3.9	1.8
Utah	2.5	2.0	2.4	2.3	2.1	1.6	1.0	1.0	1.6	1.5	1.8
Nevada	1.6	1.0	2.0	1.5	1.5	4.8	2.4	3.1	2.4	2.8	2.7
Idaho	1.5	1.7	1.7	1.6	2.0	1.7	2.5	1.9	1.5	1.9	1.5
Washington	1.9	2.2	1.7	1.9	2.2	2.2	1.9	2.3	1.8	2.1	2.3
Oregon	2.0	1.2	1.7	1.6	1.7	1.8	2.2	1.4	1.9	1.8	1.5
California	2.0	2.2	1.8	3.0	1.6	2.0	2.1	1.6	1.4	1.7	2.1
United States	1.7	1.9	1.8	1.8	1.8	2.0	2.0	2.0	1.8	1.9	1.8

[a] Four years.

March 31, and the average for each period indicated.

HORSES.

1899.	1898.	1897.	1896.	Five-year average.	1895.	1894.	1893.	1892.	1891.	Five-year average.	1890.	1889.	1888.	Three-year average.
1.5	1.5	1.2	1.5	1.4	1.0	1.8	1.7	1.1	1.7	1.5	1.3	1.0	1.2	1.2
1.2	1.6	1.7	1.3	1.5	1.7	1.6	1.7	1.4	1.5	1.6	1.3	1.7	1.5	1.5
2.0	1.5	1.6	1.7	1.7	1.5	1.7	1.6	1.5	1.2	1.5	1.3	1.0	1.1	1.1
1.8	1.5	1.6	1.2	1.5	1.3	1.4	2.2	1.7	1.6	1.6	1.3	1.2	1.0	1.2
1.9	1.8	1.4	1.1	1.5	2.4	1.4	1.5	1.2	1.2	1.5	1.0	1.1	.7	.9
1.5	1.3	1.4	1.6	1.5	2.0	2.6	2.0	1.4	1.2	1.8	1.2	1.6	1.0	1.3
2.0	2.1	2.1	2.6	2.4	1.9	2.2	1.9	1.5	1.4	1.8	1.5	1.7	1.5	1.6
2.1	2.6	1.9	2.7	2.3	1.0	2.6	1.1	1.8	1.5	1.6	1.4	1.3	1.6	1.4
2.2	1.4	1.6	2.0	1.8	1.4	2.0	1.8	1.4	1.6	1.6	1.3	1.4	1.6	1.4
2.5	2.4	2.0	2.4	2.4	......	3.6	2.3	1.7	2.0	[a]2.4	1.8	1.5	1.6	1.6
2.4	2.0	2.1	2.1	2.1	2.4	2.3	2.1	1.8	1.5	2.0	1.4	1.3	1.6	1.4
2.0	2.5	1.9	2.2	2.1	2.0	2.1	1.7	1.8	1.2	1.8	1.3	1.5	1.6	1.5
2.2	1.8	1.7	1.9	1.9	2.9	2.0	1.6	1.0	1.3	1.8	1.2	1.5	1.3	1.3
2.4	2.2	2.1	1.8	2.1	1.7	1.8	1.6	1.8	1.9	1.8	1.5	1.5	1.5	1.5
2.9	2.8	3.2	3.4	3.0	1.8	1.8	2.3	1.7	1.8	1.9	1.7	1.4	1.7	1.6
2.7	2.5	3.1	3.1	2.9	2.3	2.0	2.0	1.9	1.9	2.0	1.8	1.5	2.0	1.8
4.1	4.6	3.1	3.6	3.9	5.0	3.2	2.2	2.0	2.0	2.9	1.8	2.5	2.5	2.3
1.4	1.8	1.8	1.9	1.6	2.0	1.6	1.3	1.3	1.5	1.5	1.3	1.1	1.7	1.4
1.9	1.8	1.9	1.9	1.8	2.3	2.1	1.4	1.4	1.7	1.8	1.5	1.5	1.7	1.6
2.0	1.9	1.7	2.1	2.2	2.3	2.1	1.9	1.5	1.6	1.9	1.7	1.0	1.8	1.5
1.7	1.5	1.8	2.0	1.7	1.9	1.5	1.1	1.2	1.4	1.4	1.3	1.3	1.8	1.5
1.8	1.5	1.3	1.6	1.6	1.7	2.4	1.9	1.3	1.7	1.8	1.4	1.5	1.9	1.6
1.5	1.7	1.6	1.6	1.6	2.0	2.3	1.7	1.5	1.5	1.8	1.2	1.4	1.5	1.4
1.5	2.1	1.8	1.9	1.7	2.0	1.8	1.7	1.6	1.8	1.8	1.5	1.6	1.8	1.6
1.7	1.8	1.8	1.8	1.8	2.7	1.5	1.3	1.4	1.8	1.7	1.6	1.5	1.8	1.6
1.6	1.6	2.2	1.8	1.7	1.0	1.6	1.0	1.8	......	[a]1.4	1.4	1.3	1.8	1.5
1.8	1.7	2.1	1.5	1.7	2.8	1.6	1.3	1.3	......	[a]1.8	1.4	1.3	1.8	1.5
2.1	1.6	2.3	1.5	1.8	2.2	2.0	1.7	1.6	2.5	2.0	2.0	1.3	1.9	1.7
2.2	1.5	2.6	1.4	1.8	1.7	1.3	1.7	1.5	1.6	1.6	1.5	1.2	1.7	1.5
2.8	2.1	2.6	2.4	2.4	2.3	2.7	2.0	1.4	1.5	2.0	1.7	1.6	1.8	1.7
2.5	2.9	2.1	2.4	2.6	2.7	2.4	1.6	1.5	1.8	2.0	1.5	1.4	2.0	1.6
2.7	2.6	2.9	3.1	2.8	3.0	2.7	1.9	2.1	2.2	2.4	1.7	2.0	2.2	2.0
3.4	3.2	5.2	3.5	3.6	4.1	3.1	2.6	2.3	2.0	2.8	1.8	1.6	2.1	1.8
6.2	4.7	5.0	2.3	4.6	4.4	2.8	2.7	2.2	2.3	2.3	2.0	1.7	2.7	2.1
3.2	2.6	2.4	2.5	2.6	3.1	2.8	1.7	1.8	1.4	2.2	1.5	2.0	2.4	2.0
2.4	2.5	1.6	3.0	2.2	1.4	2.5	......	......	......	[b]2.0	......	......	......	......
2.2	1.9	2.1	2.8	2.5	3.6	2.5	2.5	2.0	2.5	2.6	1.8	2.2	2.5	2.2
3.9	1.5	1.8	2.3	2.3	1.8	2.5	2.0	1.8	1.5	1.9	3.5	1.5	2.5	2.5
1.3	1.5	2.0	1.6	1.6	2.4	1.8	1.4	1.5	1.6	1.7	3.0	1.2	......	[b]2.1
1.8	2.4	1.7	1.4	1.8	1.1	1.6	1.3	1.9	1.5	1.5	3.0	1.4	1.5	2.0
2.4	1.4	2.0	2.7	2.0	1.3	2.2	.4	2.0	2.1	1.6	1.5	3.7	2.0	2.7
.8	1.0	1.4	1.0	1.1	1.6	3.2	1.0	1.8	1.0	1.7	1.3	1.2	2.7	1.7
2.2	2.5	2.1	1.2	2.0	4.0	2.2	2.6	1.9	1.9	2.5	2.5	1.2	2.5	2.1
4.7	3.8	.9	1.6	2.7	1.0	4.1	2.2	2.0	1.8	2.2	3.5	2.8	1.1	2.5
1.8	2.2	3.5	1.7	2.1	2.5	3.1	3.5	1.5	1.6	2.4	3.3	1.2	1.6	2.0
2.2	1.6	3.9	2.0	2.4	3.8	1.1	.5	1.2	1.7	1.7	3.0	1.2	1.4	1.9
2.3	1.9	4.0	2.2	2.6	1.5	2.2	1.0	1.3	1.8	1.8	2.5	1.1	2.2	1.9
2.4	2.5	2.3	1.9	2.4	2.5	3.1	2.4	1.5	1.9	2.3	2.0	1.2	2.3	1.5
2.3	2.0	2.1	2.0	2.0	2.2	2.1	1.7	1.5	1.7	1.8	1.6	1.5	1.8	1.6

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[b] Two years.

Estimated percentage of loss from disease for the year ending

CATTLE.

State or Territory.	1908.	1907.	1906.	Three-year average.	1905.	1904.	1903.	1902.	1901.	Five-year average.	1900.	1899.	1898.
Maine	1.5	1.4	1.0	1.3	1.2	0.8	1.2	1.0	1.2	1.1	1.2	1.5	1.0
New Hampshire	1.4	2.1	1.8	1.8	1.6	1.4	2.0	2.2	1.6	1.8	1.8	1.8	1.4
Vermont	1.3	1.8	1.5	1.5	1.5	2.9	2.5	1.4	2.3	2.1	1.7	2.2	1.5
Massachusetts	2.1	1.8	1.4	1.8	1.5	1.9	3.0	2.0	1.7	2.0	1.9	1.9	1.9
Rhode Island	2.2	1.6	1.5	1.8	1.3	2.1	2.6	1.9	2.0	2.0	1.8	1.8	2.0
Connecticut	1.8	1.5	1.6	1.6	1.7	1.8	1.5	2.0	1.6	1.7	1.5	1.9	1.2
New York	2.2	2.1	1.6	2.0	1.9	1.9	2.0	2.0	1.9	1.9	2.4	2.1	2.3
New Jersey	2.0	2.1	2.0	2.0	2.3	2.3	2.7	1.7	2.3	2.3	2.2	3.3	2.5
Pennsylvania	1.8	1.8	1.5	1.7	1.7	2.0	2.0	1.9	1.7	1.9	2.1	2.2	1.8
Delaware	1.2	1.8	2.1	1.7	4.1	2.9	2.2	1.6	1.3	2.4	2.5	2.3	2.3
Maryland	1.2	1.2	1.3	1.2	1.4	1.3	1.8	2.0	1.9	1.7	1.7	1.5	1.4
Virginia	2.0	2.0	1.8	1.9	1.8	2.1	2.0	2.0	1.8	1.9	1.9	2.1	2.5
West Virginia	1.5	2.1	1.5	1.7	1.8	1.8	2.1	1.5	1.8	1.8	2.0	2.3	1.5
North Carolina	2.2	2.0	1.8	2.0	2.1	2.3	1.8	1.9	1.8	2.0	2.1	2.0	2.3
South Carolina	2.6	2.1	2.2	2.3	2.7	2.9	2.8	2.3	2.4	2.6	2.3	2.5	2.5
Georgia	2.3	2.2	2.0	2.2	2.0	3.1	3.3	2.4	2.2	2.6	2.2	1.9	3.7
Florida	3.8	3.6	3.5	3.6	3.7	4.2	2.8	3.8	3.2	3.5	3.5	3.1	4.5
Ohio	1.4	1.5	1.6	1.5	1.3	1.4	1.2	1.2	1.2	1.3	1.2	1.3	1.5
Indiana	1.6	1.7	1.5	1.6	1.5	1.8	1.5	1.6	1.4	1.6	1.5	1.8	1.4
Illinois	1.5	1.8	1.8	1.7	1.5	1.6	2.0	1.8	1.4	1.7	1.6	2.1	1.6
Michigan	1.5	1.6	1.3	1.5	1.5	1.5	1.8	1.6	1.4	1.6	1.5	1.4	1.2
Wisconsin	1.8	1.8	1.7	1.8	1.7	1.5	1.4	1.6	1.5	1.5	1.3	1.4	1.2
Minnesota	1.8	1.9	1.7	1.8	1.7	2.1	2.0	1.6	1.9	1.9	1.4	1.2	1.7
Iowa	1.7	1.7	1.5	1.6	1.7	2.0	2.1	2.2	2.0	2.0	3.0	2.0	1.7
Missouri	1.5	1.6	2.1	1.7	2.4	2.5	2.6	2.1	1.8	2.3	1.9	1.5	1.5
North Dakota	1.5	1.8	1.7	1.7	1.8	3.4	2.5	1.5	1.5	2.1	1.7	1.1	2.0
South Dakota	2.0	2.3	1.7	2.0	2.1	2.2	2.1	2.1	4.4	2.6	1.6	1.8	1.4
Nebraska	2.1	2.7	2.5	2.4	2.3	2.6	3.6	3.4	2.9	3.0	2.0	2.2	2.3
Kansas	1.2	1.6	1.5	1.4	1.5	1.8	1.9	2.1	1.9	1.8	1.9	1.7	2.1
Kentucky	2.1	1.9	2.1	2.0	2.3	2.0	2.3	2.9	1.9	2.3	2.1	1.9	1.6
Tennessee	2.1	2.3	2.1	2.2	2.6	2.7	3.0	3.2	2.2	2.7	2.8	3.0	3.2
Alabama	2.5	2.5	3.1	2.7	2.8	2.9	2.9	2.6	2.4	2.7	2.2	2.4	2.1
Mississippi	2.7	2.6	3.2	2.8	2.9	3.0	2.7	2.0	3.8	2.9	2.3	3.1	3.8
Louisiana	3.0	2.6	4.0	3.2	4.9	3.1	5.0	3.1	2.7	3.8	3.1	4.7	3.2
Texas	2.0	2.0	2.5	2.2	2.7	3.2	3.0	2.3	3.0	2.8	2.3	2.2	2.2
Indian Territory	......	2.9	3.0	[a] 2.0	3.2	2.5	3.0	3.0	4.2	3.2	......	......	......
Oklahoma	2.1	2.1	2.1	2.1	2.0	2.5	2.2	2.1	1.9	2.1	1.2	4.5	2.6
Arkansas	3.0	3.0	4.0	3.3	3.5	3.6	3.2	2.7	2.7	3.1	2.9	3.6	1.8
Montana	2.1	2.4	2.4	2.3	1.8	1.7	1.7	1.0	1.8	1.6	1.7	1.5	1.6
Wyoming	2.2	1.9	1.4	1.8	1.3	3.0	2.1	3.1	1.8	2.3	1.1	.9	2.5
Colorado	1.5	1.9	2.3	1.9	1.9	2.4	2.9	2.4	2.5	2.4	2.6	2.1	1.5
New Mexico	3.0	2.0	1.5	2.2	1.8	2.6	4.0	1.5	2.8	2.5	1.8	3.0	.8
Arizona	2.5	1.8	2.3	2.2	1.5	4.7	2.8	1.2	4.9	3.0	1.9	2.8	1.0
Utah	2.0	1.9	1.8	1.9	2.2	1.4	1.4	1.7	1.6	1.7	1.8	2.5	2.1
Nevada	1.5	2.0	3.0	2.2	2.5	3.8	2.7	1.9	1.9	2.6	1.7	1.4	2.9
Idaho	1.4	2.0	2.0	1.8	1.9	1.8	1.4	1.5	1.0	1.5	1.7	.9	1.5
Washington	1.7	2.0	1.2	1.6	1.7	1.7	1.7	1.8	1.4	1.7	1.8	1.1	1.1
Oregon	1.5	1.3	1.7	1.5	1.4	1.6	1.5	2.0	1.5	1.6	1.2	3.2	1.4
California	2.5	2.8	2.6	2.6	2.6	3.3	2.9	2.4	2.0	2.6	1.6	2.9	3.7
United States	1.9	2.0	2.0	2.0	2.1	2.4	2.4	2.1	2.2	2.2	2.0	2.0	2.0

[a] Four years.

March 31, and the average for each period indicated—Continued.

CATTLE.

1897.	1896.	Five-year average.	1895.	1894.	1893.	1892.	1891.	Five-year average.	1890.	1889.	1888.	1887.	1886.	Five-year average.
2.0	0.6	1.3	1.5	2.2	0.6	1.1	1.7	1.4	1.0	1.3	1.3	2.0	2.0	1.5
2.9	.7	1.7	2.1	2.0	.4	1.1	1.4	1.4	.9	1.1	1.6	2.5	2.0	1.6
2.5	1.0	1.8	1.6	3.2	1.4	1.2	1.1	1.7	.6	1.2	1.5	2.0	2.0	1.5
2.1	3.3	2.4	1.8	.9	1.7	1.1	1.3	1.4	.8	1.0	1.5	2.0	2.0	1.5
1.8	2.9	2.1	3.2	2.1	1.6	1.5	1.2	1.9	.8	1.0	1.2	2.0	2.0	1.4
1.9	1.9	1.7	1.9	2.7	1.2	1.8	1.5	1.8	1.3	1.8	1.3	2.0	2.0	1.7
2.2	2.2	2.2	2.4	2.5	2.6	1.5	1.7	2.1	1.6	2.0	2.2	2.5	2.0	2.1
1.6	2.2	2.4	1.8	3.0	1.1	1.3	1.9	1.8	1.7	1.9	.9	2.0	2.0	1.7
1.8	1.7	1.9	1.9	1.8	1.6	1.5	1.5	1.7	1.7	1.3	1.9	3.0	2.0	2.0
2.4	3.6	2.8	......	1.0	1.2	2.0	1.1	[a] 1.3	2.4	1.2	2.3	3.0	4.0	2.6
2.1	2.6	1.9	2.5	1.8	2.0	1.5	1.3	1.8	1.7	1.8	2.0	4.0	3.0	2.5
2.1	2.3	2.2	1.5	1.5	1.8	1.5	1.6	1.6	1.8	1.9	2.4	4.0	4.0	2.8
1.7	1.5	1.8	2.1	1.4	1.4	.5	.8	1.2	.7	2.0	2.0	3.0	3.0	2.1
1.8	1.9	2.0	2.4	1.7	1.6	2.3	2.1	2.0	2.2	2.2	2.9	6.0	6.0	3.9
2.1	2.6	2.4	2.0	1.4	2.2	1.5	2.4	1.9	2.3	2.1	2.8	6.0	6.0	3.8
2.5	2.2	2.5	2.8	3.1	2.2	1.8	2.3	2.4	1.3	3.4	3.0	7.0	7.0	4.3
2.6	2.7	3.3	2.1	4.3	1.7	3.0	3.5	2.9	3.5	5.5	3.5	7.0	8.0	5.5
1.4	1.2	1.3	1.2	1.3	1.4	.9	1.1	1.2	.8	1.5	1.8	3.0	2.0	1.8
1.7	1.5	1.6	2.5	1.1	1.8	1.2	1.2	1.6	.7	2.0	1.6	4.0	2.0	2.1
1.6	1.7	1.7	2.7	1.6	1.3	1.3	1.2	1.6	.9	1.9	2.0	3.0	2.0	2.0
1.4	1.5	1.4	1.7	1.0	.4	1.1	1.3	1.1	1.3	1.8	1.4	3.0	2.0	1.9
1.3	1.4	1.3	1.1	1.5	1.8	1.7	1.7	1.6	1.2	1.9	2.1	2.5	2.0	1.9
1.4	1.5	1.4	1.7	1.4	1.3	1.0	1.7	1.4	1.4	2.0	2.2	2.0	2.0	1.9
2.2	1.9	2.2	2.0	1.4	.5	1.3	2.0	1.4	1.5	1.6	2.5	3.0	2.0	2.1
1.7	1.6	1.6	1.7	1.4	.9	.8	1.6	1.3	1.2	2.0	2.7	3.0	3.0	2.4
1.7	2.1	1.7	1.7	1.0	1.0	.5	1.2	1.1	.8	2.0	3.4	4.0	3.0	2.6
2.3	1.8	1.8	2.4	1.2	1.5	.4	1.2	1.3	.8	2.0	3.4	4.0	3.0	2.6
2.0	1.8	2.1	1.8	1.4	2.1	.5	2.5	1.7	2.0	2.2	3.5	3.0	3.0	2.7
1.9	2.1	1.9	1.4	1.6	1.5	.5	1.8	1.4	1.8	1.8	2.3	4.0	3.0	2.6
1.9	1.8	1.9	1.7	1.8	1.8	.7	.8	1.4	.7	1.8	2.5	3.0	2.0	2.0
2.6	2.1	2.7	2.1	2.4	1.0	.7	1.2	1.5	1.4	1.7	2.7	5.0	6.0	3.4
2.1	2.4	2.2	2.3	2.8	2.3	1.2	.9	1.9	.9	3.0	3.7	6.0	6.0	3.9
2.8	3.0	3.0	4.3	2.1	1.6	2.0	1.3	2.3	.9	3.2	3.5	7.0	6.0	4.1
2.8	2.7	3.3	4.7	2.4	3.1	1.2	1.0	2.5	1.5	3.4	4.0	6.0	7.0	4.4
1.6	2.3	2.1	3.4	3.3	2.0	1.7	.7	2.2	.4	3.5	4.5	7.0	6.0	4.3
......	......	......	......	......	......	......	......	......	......	......	4.0	......	6.0	[b] 5.0
1.5	1.5	2.3	......	......	......	......	......	......	......	......	......	......	......	......
2.1	2.1	2.5	2.3	2.8	2.4	1.7	2.8	2.4	3.2	2.6	3.2	8.0	7.0	4.8
2.1	1.7	1.7	2.0	.9	5.0	.3	1.5	1.9	2.5	2.5	3.5	9.0	4.0	4.3
2.4	.9	1.6	1.6	.3	2.2	.2	.5	1.0	1.0	2.7	2.5	6.0	4.0	2.2
2.1	1.5	2.0	2.0	2.7	1.5	1.3	1.2	1.7	1.4	3.0	5.5	4.5	6.0	4.1
5.0	4.1	2.9	1.7	2.1	4.0	2.8	1.6	2.4	1.2	4.2	3.7	4.0	5.0	3.6
1.7	2.5	2.0	.0	......	.2	3.5	1.0	[a] 1.2	1.0	3.5	5.0	4.0	5.0	2.7
1.4	1.9	1.9	2.3	3.6	3.3	2.4	1.0	2.5	2.7	3.7	3.5	4.0	3.0	3.4
1.2	1.4	1.7	.5	1.7	.8	2.0	1.4	1.3	4.0	3.5	3.0	4.5	4.0	3.8
1.4	1.9	1.5	.6	1.4	.3	1.5	1.2	1.0	2.8	2.0	3.3	9.0	4.0	4.2
1.2	1.5	1.3	1.2	1.0	.5	.8	.5	.8	3.5	2.5	2.7	3.0	3.0	2.9
1.4	1.2	1.7	1.3	.7	.5	.8	.6	.8	3.0	2.0	2.2	5.0	4.0	3.2
1.9	2.4	2.5	2.1	1.1	1.4	1.2	2.0	1.6	3.0	2.3	4.5	4.0	4.0	3.6
1.9	2.0	2.0	2.1	1.9	1.7	1.3	1.5	1.7	1.3	2.4	2.9	4.4	4.0	3.0

[b] Two years.

Estimated percentage of loss from disease for the year ending

SHEEP.

State or Territory.	1908.	1907.	1906.	Three-year average.	1905.	1904.	1903.	1902.	1901.	Five-year average.	1900.	1899.	1898.
Maine	2.2	2.1	2.5	2.3	3.8	2.2	2.0	1.6	2.0	2.3	2.5	2.8	2.2
New Hampshire	2.2	2.5	2.4	2.4	2.0	3.7	2.7	2.8	3.7	3.0	2.7	2.2	2.7
Vermont	2.2	1.6	2.0	1.9	2.0	2.5	2.7	2.5	2.2	2.4	2.2	3.4	2.1
Massachusetts	1.9	2.2	1.5	1.9	1.4	1.0	1.4	1.6	1.6	1.4	1.2	1.3	1.4
Rhode Island	1.4	1.4	1.5	1.4	1.0	1.2	2.0	1.7	2.0	1.6	2.3	2.8	1.8
Connecticut	2.1	2.4	2.4	2.3	3.2	3.0	3.1	2.2	1.9	2.7	1.6	2.2	1.6
New York	2.9	2.3	2.0	2.4	2.7	1.7	2.5	2.5	2.5	2.4	2.6	2.6	2.8
New Jersey	2.5	2.6	2.0	2.4	2.5	1.9	3.2	2.2	2.4	2.4	2.3	1.8	4.4
Pennsylvania	2.6	3.0	2.2	2.6	2.8	2.8	2.9	2.9	2.9	2.9	3.3	3.2	1.9
Delaware	1.6	2.5	2.5	2.2	2.6	3.4	3.0	3.2	2.4	2.9	2.2	1.8	1.8
Maryland	2.6	2.5	2.5	2.5	2.6	2.2	2.9	3.1	2.5	2.7	2.5	2.5	2.9
Virginia	3.8	3.5	3.0	3.4	3.4	3.3	3.2	4.0	3.0	3.4	2.8	2.6	2.6
West Virginia	2.8	3.5	3.5	3.3	3.3	3.4	3.9	3.3	3.6	3.5	3.8	3.8	3.4
North Carolina	2.0	2.0	2.2	2.1	3.3	3.1	2.3	2.3	2.1	2.6	2.6	2.4	3.0
South Carolina	2.6	2.3	2.3	2.4	3.1	3.5	3.3	3.5	2.0	3.1	2.6	2.8	2.6
Georgia	3.0	3.2	2.5	2.9	2.9	5.1	4.9	4.7	2.2	4.0	3.6	2.7	1.9
Florida	4.0	3.2	3.0	3.4	3.2	3.2	3.2	5.1	2.5	3.4	3.5	2.7	11.5
Ohio	2.8	2.9	3.0	2.9	2.3	2.4	2.3	2.9	2.8	2.5	1.9	2.8	2.8
Indiana	3.7	3.1	3.0	3.3	2.3	3.2	3.3	2.9	3.2	3.0	3.1	3.4	2.3
Illinois	2.6	2.2	3.0	2.6	2.2	2.3	3.4	2.1	2.4	2.5	2.4	2.7	1.8
Michigan	3.0	2.8	2.6	2.8	2.6	3.5	3.4	3.2	3.6	3.3	2.9	2.5	2.5
Wisconsin	1.9	2.2	2.0	2.0	1.9	2.7	2.3	2.0	2.2	2.2	1.9	2.1	2.7
Minnesota	2.0	1.9	1.8	1.9	1.9	2.7	2.6	1.9	2.0	2.2	1.8	1.3	1.7
Iowa	2.5	2.6	2.3	2.5	2.6	2.6	3.1	2.4	3.0	2.7	3.6	3.3	2.1
Missouri	2.6	2.4	3.3	2.8	3.1	3.2	3.0	2.5	2.4	2.8	2.7	2.1	2.2
North Dakota	2.0	2.3	1.6	2.0	1.9	3.8	4.0	1.6	1.8	2.6	1.7	1.0	1.7
South Dakota	2.1	2.3	2.1	2.2	2.7	2.4	2.8	2.5	2.0	2.5	1.5	1.7	0.9
Nebraska	2.4	2.7	2.5	2.5	1.9	2.7	3.6	2.2	0.9	2.3	1.0	1.2	1.9
Kansas	1.1	1.3	1.0	1.1	1.3	1.2	1.9	1.8	1.0	1.4	1.0	1.7	1.7
Kentucky	3.5	3.0	3.0	3.2	4.0	3.5	3.3	4.1	3.3	3.6	3.6	4.2	2.6
Tennessee	2.6	2.5	2.5	2.5	3.4	3.4	3.2	3.2	2.8	3.2	3.2	3.3	4.1
Alabama	2.9	3.2	4.0	3.4	2.9	6.1	4.3	2.9	2.7	3.8	2.9	2.8	3.0
Mississippi	4.2	6.5	6.0	5.6	3.7	3.9	3.0	2.5	5.3	3.7	2.5	3.3	3.9
Louisiana	2.4	3.0	3.5	3.0	4.3	4.9	4.3	2.8	2.4	3.7	3.6	4.1	4.1
Texas	1.8	2.8	3.0	2.5	3.1	2.3	3.3	4.3	2.4	3.1	2.1	2.2	2.6
Indian Territory	1.7	1.3	2.0	1.7	1.1	3.7	3.2	2.0	1.5	2.3			
Oklahoma	1.7	3.0	1.8	2.2	5.4	2.0	2.4	2.5	1.3	2.7	1.0	0.4	1.7
Arkansas	2.5	2.2	2.0	2.2	3.4	3.1	2.4	2.6	3.2	2.9	2.7	3.5	1.9
Montana	1.3	3.4	1.7	2.1	2.0	1.8	2.0	1.8	1.4	1.8	1.9	1.8	2.6
Wyoming	3.0	3.0	1.5	2.5	2.4	2.0	2.1	1.4	1.9	2.0	1.0	1.0	5.7
Colorado	1.9	2.0	1.8	1.9	2.5	3.2	3.0	2.8	1.5	2.6	0.9	1.8	5.1
New Mexico	2.2	1.7	1.5	1.8	2.9	2.4	5.1	3.4	4.0	3.6	1.7	1.6	1.8
Arizona	1.6	3.0	1.6	2.1	1.6	3.3	3.0	2.0	2.2	2.4	1.2	1.5	0.9
Utah	1.5	1.0	1.5	1.3	2.1	2.2	2.1	2.9	2.1	2.3	2.0	2.1	3.8
Nevada	2.5	3.0	3.0	2.8	4.4	4.8	2.0	2.4	1.6	3.0	2.7	0.6	1.6
Idaho	1.8	1.8	2.5	2.0	2.1	2.5	2.1	2.1	2.4	2.2	1.8	1.0	1.2
Washington	1.5	2.6	2.0	2.0	2.0	2.3	2.1	1.9	2.8	2.2	2.0	1.1	1.5
Oregon	1.1	1.5	2.5	1.7	1.8	2.3	2.2	1.5	2.2	2.0	1.9	3.0	1.4
California	2.5	4.0	2.6	3.0	2.2	3.0	3.3	2.1	1.6	2.4	2.8	2.5	2.2
United States	2.2	2.6	2.2	2.3	2.5	2.6	2.8	2.5	2.4	2.6	2.0	2.1	2.6

March 31, and the average for each period indicated—Continued.

SHEEP.

1897.	1896.	Five-year average.	1895.	1894.	1893.	1892.	1891.	Five-year average.	1890.	1889.	1888.	1887.	1886.	Five-year average.
2.2	1.9	2.3	2.4	3.5	2.0	2.5	2.7	2.6	2.2	2.6	3.1	5.0	4.0	3.4
3.8	1.8	2.6	3.0	4.3	1.4	2.6	2.8	2.8	2.3	2.0	3.5	4.0	4.0	3.2
2.7	0.8	2.2	3.3	2.3	1.7	2.5	2.7	2.5	2.3	2.3	3.0	4.0	4.0	3.1
2.2	3.0	2.0	14.6	1.6	1.2	1.7	1.9	4.2	2.0	1.8	3.0	4.0	4.0	3.0
2.1	5.0	2.8	2.6	3.8	0.5	1.8	2.7	2.3	2.4	1.5	2.0	4.0	3.0	2.6
4.0	2.6	2.4	4.7	2.1	1.7	2.3	2.5	2.7	1.9	2.5	2.5	4.0	4.0	3.0
3.1	3.3	2.9	4.7	2.3	2.8	2.6	2.1	2.9	1.9	2.7	3.3	4.0	4.0	3.2
2.2	2.5	2.6	2.3	4.5	2.8	2.6	2.5	2.9	1.9	1.5	1.8	5.0	3.0	2.6
2.8	3.1	2.9	6.5	1.6	5.6	1.9	2.6	3.6	1.7	3.0	3.2	4.0	3.0	3.0
4.1	6.2	3.2	......	1.4	1.9	2.0	2.0	[a]1.8	2.5	2.0	3.0	5.0	5.0	3.5
2.9	2.7	2.7	1.9	3.4	2.0	1.9	2.7	2.4	2.4	2.2	2.1	4.0	4.0	2.9
3.4	3.3	2.9	4.5	2.5	3.3	1.9	2.3	2.9	2.1	3.5	4.1	9.0	8.0	5.3
3.1	3.9	3.6	2.6	2.9	3.6	1.0	2.5	2.5	2.3	3.6	4.0	6.0	7.0	4.6
2.8	2.8	2.7	3.0	3.0	2.2	1.5	3.3	2.6	2.8	3.7	4.6	11.0	8.0	6.0
5.5	3.3	3.4	1.7	2.8	3.2	2.0	2.5	2.4	3.1	3.6	4.1	7.0	8.0	5.2
4.7	3.5	3.3	6.2	1.0	4.4	2.7	3.6	3.6	3.0	6.0	5.0	13.0	12.0	7.8
3.2	2.9	4.8	3.8	2.8	2.2	3.6	6.5	3.8	6.5	5.9	5.5	11.0	12.0	8.2
3.8	2.4	2.7	2.7	2.3	1.8	1.5	1.5	2.0	1.7	3.3	3.5	5.0	4.0	3.5
4.1	3.3	3.2	4.1	3.0	3.8	1.9	3.3	3.2	3.0	3.2	4.7	7.0	6.0	4.8
3.3	2.7	2.6	4.3	2.0	2.1	1.6	2.5	2.5	2.2	3.0	4.4	6.0	5.0	4.1
2.9	2.5	2.7	4.2	1.9	1.9	1.3	2.8	2.4	1.9	2.6	2.4	4.0	4.0	3.0
1.9	2.8	2.3	2.3	2.6	2.8	1.4	2.4	2.3	2.0	3.5	3.7	5.0	5.0	3.8
1.7	1.8	1.7	2.8	2.0	1.6	1.0	2.6	2.0	2.6	3.0	4.0	5.0	4.0	3.7
4.0	2.5	3.3	2.7	1.7	1.1	1.1	2.2	1.8	1.2	3.5	3.2	6.5	5.0	3.9
3.1	2.9	2.6	3.2	2.0	1.0	1.4	2.7	2.1	1.5	3.9	4.0	7.0	7.0	4.7
1.9	2.3	1.7	4.0	2.1	2.0	1.8	2.4	2.5	1.0	3.2	4.2	6.0	4.0	3.7
2.5	1.6	1.6	3.0	3.2	2.8	1.6	2.4	2.6	1.0	3.2	4.2	6.0	4.0	3.7
1.3	1.9	1.5	3.1	2.1	0.8	1.3	3.1	2.1	1.8	2.8	3.5	6.0	6.0	4.0
1.3	1.6	1.5	0.9	1.7	1.2	1.1	1.8	1.3	1.7	2.6	3.5	6.0	7.0	4.2
2.8	3.6	3.6	2.9	3.1	1.5	1.2	3.0	2.3	3.0	3.8	4.3	8.0	6.0	5.0
3.1	3.2	3.4	3.8	3.5	4.2	1.8	3.2	3.3	3.0	3.8	4.9	11.0	12.0	6.9
2.7	3.6	3.2	3.6	0.3	4.1	3.5	3.7	3.0	2.9	4.5	7.0	12.0	12.0	7.7
3.1	3.8	2.3	4.2	2.4	3.4	3.2	3.7	3.4	4.5	4.6	6.0	13.0	10.0	7.6
3.6	4.1	3.9	5.2	1.4	3.7	1.9	4.0	3.2	5.7	4.7	5.0	11.0	11.0	7.5
2.1	3.5	2.5	3.3	2.2	3.4	2.3	2.0	2.6	2.2	4.2	5.5	9.0	13.0	6.8
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
1.1	0.5	0.9	......	......	......	......	......	......	......	......	......	......	......	......
4.3	2.8	3.0	3.8	4.0	2.5	1.8	3.2	3.1	2.5	4.0	4.7	11.0	13.0	7.0
1.0	1.7	1.8	1.0	0.8	1.3	.8	2.0	1.2	2.2	3.2	4.4	11.0	4.0	5.0
0.0	3.2	2.2	1.6	2.0	0.6	.9	1.7	1.4	2.0	3.0	5.1	5.0	5.0	4.0
1.3	2.6	2.3	3.3	1.1	2.3	1.5	1.6	2.0	1.4	5.0	5.2	9.0	8.0	5.7
2.8	2.8	2.1	0.6	1.8	4.2	3.0	2.5	2.4	2.7	5.0	5.7	6.0	7.0	5.3
1.0	1.0	1.1	0.1	......	1.0	3.0	2.0	[a]1.5	2.3	4.4	4.3	8.0	7.0	5.2
1.8	1.5	2.2	2.4	1.9	2.3	2.7	3.7	2.6	2.2	5.5	6.5	8.0	6.0	5.6
1.4	0.9	1.4	0.0	4.0	1.1	2.3	1.9	1.9	6.5	5.0	3.7	8.0	8.0	6.2
1.9	1.8	1.5	1.0	1.0	1.3	1.8	2.0	1.4	1.1	3.0	6.0	10.0	5.0	5.0
1.6	1.3	1.5	0.7	0.8	2.6	0.7	1.8	1.3	3.4	2.9	3.5	8.0	7.0	5.0
2.0	2.8	2.2	1.6	1.1	1.2	0.9	1.7	1.3	3.0	4.2	5.1	7.0	5.0	4.9
2.7	4.7	3.0	2.9	2.4	1.9	1.8	1.9	2.2	3.4	4.2	5.7	8.0	6.0	5.5
2.3	2.7	2.3	2.6	2.0	2.4	1.9	2.3	2.2	2.4	3.8	4.6	7.0	7.0	5.0

[a] Four years.

Estimated percentage of loss from disease for the year ending

SWINE.

State or Territory.	1908.	1907.	1906.	Three-year average.	1905.	1904.	1903.	1902.	1901.	Five-year average.	1900.	1899.	1898.
Maine	1.1	1.0	1.2	1.1	1.2	1.0	1.4	0.9	1.5	1.2	1.3	1.8	1.3
New Hampshire	1.5	1.4	2.0	1.6	2.2	1.5	1.2	1.9	1.4	1.6	2.0	2.0	2.4
Vermont	1.5	1.4	1.7	1.5	1.8	1.5	2.4	2.0	2.4	2.0	1.8	2.5	1.7
Massachusetts	2.2	2.5	1.8	2.2	2.0	2.3	2.5	2.1	1.6	2.1	2.2	1.9	1.0
Rhode Island	2.3	1.2	1.9	1.8	2.2	2.5	2.4	1.9	2.4	2.3	1.8	3.1	2.7
Connecticut	2.3	1.8	2.0	2.0	2.3	2.8	3.0	2.4	1.9	2.5	1.7	1.9	1.6
New York	1.8	2.1	1.9	1.9	1.7	3.3	1.8	1.9	1.9	2.1	2.0	2.4	2.5
New Jersey	2.4	2.8	2.2	2.5	2.2	3.2	3.3	2.3	2.5	2.7	2.7	4.3	4.0
Pennsylvania	2.7	2.8	2.3	2.6	2.3	2.7	3.6	3.2	2.4	2.8	2.5	3.2	3.0
Delaware	2.8	3.0	3.0	2.9	4.3	10.1	5.8	3.7	2.7	5.3	5.7	4.7	5.9
Maryland	2.9	3.0	3.5	3.1	4.3	3.1	3.2	3.3	4.7	3.7	3.7	4.2	7.1
Virginia	4.6	4.5	4.0	4.4	4.3	5.5	6.1	4.6	4.3	5.0	4.5	3.7	7.8
West Virginia	2.5	3.3	3.1	3.0	3.6	3.5	3.6	2.6	3.1	3.3	4.9	4.9	7.0
North Carolina	6.0	6.5	5.5	6.0	9.7	9.6	6.4	8.0	4.9	7.7	6.5	6.1	9.1
South Carolina	5.7	5.5	5.0	5.4	8.5	7.5	6.6	8.2	6.1	7.4	7.3	8.2	7.5
Georgia	4.4	5.0	5.5	5.0	5.1	8.9	11.8	8.9	10.3	9.0	9.4	9.0	10.8
Florida	7.3	6.8	7.5	7.2	8.2	7.2	11.3	10.4	9.1	9.2	11.8	8.5	14.9
Ohio	3.5	4.0	5.0	4.2	3.8	5.0	5.0	4.1	5.5	4.7	4.6	6.5	7.2
Indiana	5.2	5.8	6.0	5.7	5.4	7.8	7.3	4.1	5.6	6.0	6.9	11.5	7.4
Illinois	6.0	4.8	6.0	5.6	4.6	5.8	7.4	4.7	7.7	6.0	6.8	10.4	10.4
Michigan	3.0	3.1	2.2	2.8	2.5	3.7	3.0	2.9	3.6	3.1	2.9	3.9	2.3
Wisconsin	2.3	2.4	2.0	2.2	2.2	2.7	2.5	3.1	10.3	4.2	3.1	4.9	5.0
Minnesota	3.0	3.3	3.0	3.1	2.1	3.0	3.9	3.5	9.4	4.4	8.4	7.9	12.0
Iowa	6.9	5.0	4.5	5.5	4.2	5.5	5.3	4.8	8.9	5.7	7.7	17.4	17.5
Missouri	7.0	5.4	6.5	6.3	7.4	7.7	6.7	4.4	4.8	6.2	7.0	9.0	11.0
North Dakota	1.1	1.6	1.1	1.3	1.3	2.4	2.0	1.4	2.4	1.9	2.2	1.8	2.0
South Dakota	4.5	6.1	9.5	6.7	2.3	5.4	6.8	8.2	10.0	6.5	3.9	6.2	22.0
Nebraska	7.0	7.5	8.8	7.8	4.6	5.7	7.7	6.5	14.0	7.7	7.4	9.8	12.8
Kansas	4.0	3.7	3.4	3.7	3.4	3.9	3.5	3.2	5.0	3.8	6.0	6.5	7.0
Kentucky	6.2	5.2	5.5	5.6	6.3	7.1	5.9	5.9	6.7	6.4	8.1	8.5	10.0
Tennessee	5.5	5.3	4.7	5.2	7.3	7.9	6.4	6.1	9.0	7.3	9.2	9.6	9.3
Alabama	5.6	5.5	6.0	5.7	5.7	8.2	7.1	6.9	9.4	7.5	7.8	7.3	7.9
Mississippi	7.5	5.7	6.0	6.4	6.9	8.1	4.1	5.7	8.5	6.7	5.4	7.9	8.6
Louisiana	8.5	8.0	12.0	9.5	11.3	8.5	11.6	9.9	7.5	9.8	10.1	11.4	12.5
Texas	3.0	4.0	4.2	3.7	5.5	3.7	4.0	6.1	5.9	5.0	3.9	3.9	5.6
Indian Territory	......	4.3	5.5	[b]4.9	16.0	7.8	10.3	8.1	10.5	10.5	......	......	......
Oklahoma	4.0	5.0	2.2	3.7	2.3	2.4	2.5	2.7	4.6	2.9	.5	4.7	4.8
Arkansas	9.1	7.5	8.0	8.2	12.2	10.8	7.0	8.7	12.3	10.2	12.2	10.8	12.8
Montana	1.9	2.0	4.4	2.8	1.1	.9	1.7	.9	.9	1.1	.8	2.4	.8
Wyoming	2.0	2.5	.4	1.6	1.9	3.4	.7	1.1	.5	1.5	.3	.5	.4
Colorado	3.1	2.0	2.5	2.5	2.4	1.5	2.3	3.0	1.6	2.2	1.7	.9	1.8
New Mexico	1.5	1.7	1.5	1.6	1.8	.8	2.0	1.0	3.0	1.7	.9	.2	.5
Arizona	1.0	1.5	2.0	1.5	9.4	5.3	2.2	2.2	2.1	4.2	.8	.2	.1
Utah	4.2	.6	4.0	2.9	1.4	1.0	2.0	.5	1.1	1.2	.9	1.2	1.3
Nevada	3.0	4.0	2.0	3.0	2.1	1.8	1.6	1.0	1.9	1.7	4.7	.6	.2
Idaho	1.1	1.3	1.5	1.3	1.1	2.8	2.5	2.4	2.3	2.2	1.5	3.8	.3
Washington	1.5	1.8	1.3	1.5	1.6	2.0	1.8	2.4	2.3	2.0	3.3	1.1	1.1
Oregon	1.6	1.0	1.2	1.3	1.5	1.3	2.7	2.7	3.0	2.2	2.2	1.5	1.8
California	2.5	5.0	3.2	3.6	3.3	4.5	5.7	6.1	5.3	5.0	2.8	5.6	3.3
United States	5.2	4.9	5.1	5.1	5.1	5.8	5.8	5.2	7.5	5.9	6.4	8.2	9.3

[a] Three years.

[b] Two years.

March 31, and the average for each period indicated—Continued.

SWINE.

1897.	1896.	Five-year average.	1895.	1894.	1893.	1892.	1891.	Five-year average.	1890.	1889.	1888.	1887.	1886.	Five-year average.
2.3	2.0	1.7	3.4	0.8	1.6	1.4	1.7	1.8	2.2	1.3	1.4	4.0	5.0	2.8
2.3	2.2	2.2	2.4	3.4	1.6	1.6	2.0	2.2	2.0	1.8	2.0	4.0	3.0	2.6
2.4	1.8	2.0	5.1	1.5	3.3	1.8	1.7	2.7	2.2	1.5	1.8	3.0	3.0	2.3
1.8	1.6	1.8	2.2	2.0	2.3	1.4	2.0	2.0	2.0	1.3	2.3	4.0	4.0	2.7
2.3	2.1	2.4	1.8	2.7	1.6	1.7	1.6	1.9	1.8	1.5	1.3	3.0	3.0	2.1
2.5	1.0	1.7	4.3	4.7	3.7	2.3	2.5	3.5	1.8	1.4	2.0	5.0	3.0	2.6
2.2	3.2	2.7	2.6	2.8	3.1	1.9	2.0	2.5	2.5	2.5	2.2	4.5	4.0	3.1
2.2	6.5	4.1	9.2	1.4	1.4	1.8	2.4	3.2	2.0	2.0	1.6	5.0	3.0	2.7
3.1	3.6	3.1	3.0	2.1	2.8	2.0	2.7	2.5	3.0	2.3	3.0	9.0	4.0	4.3
5.3	4.0	5.1	......	......	3.1	4.0	5.0	[a] 4.0	7.0	10.0	3.7	6.5	8.0	7.0
5.8	3.5	4.9	4.5	2.3	2.3	3.5	4.5	3.4	6.4	4.1	7.3	20.0	12.0	10.0
7.5	6.5	6.0	4.4	3.0	6.5	5.3	5.5	4.9	7.5	5.0	7.4	27.0	12.0	11.8
7.0	5.0	5.9	2.3	2.2	2.8	5.0	4.5	3.4	8.6	4.8	6.7	10.0	6.0	7.2
9.8	11.0	8.5	8.1	6.1	9.5	7.0	7.2	7.6	10.0	6.3	8.0	20.0	13.0	11.5
9.1	11.0	8.6	10.0	8.5	7.2	6.2	5.0	7.4	8.5	7.5	7.4	13.0	14.0	10.1
12.6	11.5	10.7	10.2	7.6	10.5	9.7	8.5	9.3	9.0	13.0	7.5	15.0	13.0	11.5
10.8	13.0	11.8	13.6	8.1	20.0	7.5	11.0	12.0	10.7	12.5	9.0	13.0	25.0	13.8
10.8	8.2	7.5	5.0	3.3	3.4	4.0	6.0	4.3	5.4	3.8	5.7	8.0	5.0	5.6
22.8	14.8	12.9	7.5	2.0	5.0	6.0	9.4	6.2	9.3	6.5	9.0	11.0	7.0	8.6
14.5	24.2	13.3	14.5	3.9	5.3	7.5	8.5	7.9	7.0	6.0	8.6	18.0	15.0	10.9
3.5	3.8	3.5	2.3	1.7	2.0	5.2	3.5	2.9	4.0	2.3	6.1	5.0	5.0	4.5
3.3	4.1	4.1	4.9	3.2	4.0	4.1	4.2	4.1	3.2	4.6	5.7	5.0	4.0	4.5
2.3	5.3	9.8	3.6	2.0	2.6	4.0	2.4	2.9	3.0	3.4	2.6	4.0	3.0	3.2
22.9	20.7	19.2	10.6	4.2	8.4	5.3	8.2	7.3	7.5	5.0	8.2	10.0	13.0	8.7
16.7	20.0	12.7	11.6	5.8	5.4	5.0	12.0	8.0	8.0	6.7	9.5	18.0	16.0	11.6
4.8	2.0	2.6	2.2	1.2	3.8	3.2	4.5	3.0	7.5	3.4	4.7	6.0	8.0	5.9
14.4	9.0	11.1	7.1	4.0	3.5	2.9	4.5	4.4	7.5	3.4	4.7	6.0	8.0	5.9
12.9	13.6	11.9	12.6	5.6	4.6	4.0	14.5	8.3	8.5	5.5	8.5	10.0	17.0	9.9
16.8	13.0	8.7	7.8	4.5	4.0	3.7	10.0	6.0	5.8	5.8	7.7	13.0	18.0	10.1
14.6	10.5	10.5	14.2	6.9	5.5	4.2	9.8	8.1	9.5	6.3	8.0	12.0	9.0	10.0
12.8	12.0	10.8	16.2	7.1	5.0	7.2	10.0	9.1	9.3	9.7	11.7	19.0	13.0	13.1
14.0	13.0	10.0	11.6	6.9	12.0	8.0	8.2	9.3	10.3	11.0	8.0	17.0	20.0	13.3
15.2	12.0	9.8	8.8	5.8	9.0	8.6	8.2	8.1	11.5	8.0	9.0	20.0	18.0	13.3
27.5	11.5	14.8	9.4	6.2	10.6	5.3	9.4	8.2	9.3	9.0	9.5	18.0	16.0	12.4
11.6	8.0	6.6	6.0	4.7	5.9	3.7	7.8	5.6	7.5	5.5	7.3	13.0	20.0	10.7
......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
3.4	2.5	3.6	......	......	......	......	......	......	......	......	......	......	......	......
11.0	18.0	15.0	11.2	8.3	12.3	8.6	11.0	10.3	10.6	10.5	12.5	20.0	22.0	15.1
4.3	.8	1.8	3.5	1.4	1.5	2.0	3.0	2.3	6.0	2.5	3.0	8.0	5.0	4.9
.8	1.7	.7	0	1.0	1.0	1.5	4.0	1.5	5.0	2.5	3.5	5.0	3.0	3.8
2.7	6.0	2.6	3.0	1.5	1.2	1.6	2.2	1.9	5.0	2.0	4.0	5.0	3.0	3.8
5.8	2.6	2.0	1.7	1.0	1.2	3.7	4.3	2.4	5.0	6.7	8.0	6.0	6.0	6.3
9.0	1.3	2.3	3.2	......	1.5	3.0	3.0	[c] 2.7	6.0	2.5	4.0	5.0	3.0	4.1
3.0	2.0	1.7	3.2	1.1	2.3	1.5	4.0	2.4	5.4	5.0	5.1	4.0	4.0	4.7
1.5	2.3	1.9	0	8.0	3.5	3.2	2.5	3.4	3.5	2.0	3.0	8.0	5.0	4.3
4.1	2.0	2.3	.7	......	3.0	3.0	3.2	[c] 2.5	6.0	3.0	3.7	5.0	5.0	4.5
3.6	3.0	2.4	2.1	2.4	1.0	2.5	2.5	2.1	5.8	2.6	2.7	4.0	5.0	4.0
2.5	2.2	2.2	1.2	1.0	3.7	2.4	2.3	2.1	6.7	2.3	3.0	5.0	3.0	4.0
5.2	8.0	5.0	4.9	1.8	2.9	3.1	4.8	3.5	5.9	2.5	4.0	10.0	5.0	5.5
14.4	12.7	10.2	9.2	4.9	6.3	5.4	8.4	6.8	7.6	6.2	7.8	13.4	13.0	9.6

[a] Four years.

DISEASES OF LIVE STOCK.

By A. D. Melvin,
Chief of Bureau of Animal Industry, U. S. Department of Agriculture.

The Bureau of Statistics of this department has submitted to the commission a statement showing the estimated losses of farm animals from disease and exposure for a number of years. The commission should consider in its report the losses from exposure as well as those from disease, as such losses are unquestionably large in the open range country during severe winters. It is believed that the numbers lost could be greatly reduced by leasing the range and allowing stock owners to fence it and to build sheds for the protection of the animals.

There is no doubt that by far the greater part of the losses of hogs from disease is due to hog cholera. For several years this bureau has been making investigations to determine the cause and develop a remedy, and recently a method of treatment has been worked out which is shown to be very effective in preventing the disease. The department is now endeavoring to induce the authorities of the various States to undertake the production of serum or vaccine according to the bureau's method and to supply this remedy to hog raisers in their respective States. If this plan can be carried out, especially in the large hog-raising States where cholera prevails, losses on account of this disease can unquestionably be greatly reduced.

The southern cattle tick (*Margaropus annulatus*) is the cause of heavy losses to the live-stock industry in the section where this parasite prevails. The infected area includes all or parts of the States of Virginia, North Carolina, South Carolina, Tennessee, Georgia, Florida, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas, and California. This tick not only spreads the contagion of southern or Texas fever of cattle, but does considerable injury to the animals simply as a bloodsucking parasite. It is estimated that this tick is responsible for an annual loss of about $40,000,000 to the people of the infected country and that it also lowers the assets of the South by an additional $23,250,000.

The remedy for this condition is to exterminate the ticks, and this work has been in progress since the summer of 1906 by cooperation between the federal and state authorities. Within that time an area of over 63,000 square miles has been freed from the ticks and the practicability of their ultimate eradication has been demonstrated, although the undertaking will undoubtedly require several years and the expenditure of considerable money. It is believed, however, that the benefits will amply justify the expenditure.

Other sources of losses are the diseases known as scabies of sheep and cattle. Before this bureau undertook to control and eradicate these diseases, their presence in this country threatened serious injury to our export trade in live stock. While these diseases are not often directly fatal, they reduce the strength and vitality of the animals to such an extent that many die from exposure during severe weather.

There are also losses from reduction in flesh, and, in the case of sheep, decrease in wool production. For several years this bureau, in cooperation with State authorities, has been endeavoring to eradicate these diseases and good progress has been made. They have been entirely wiped out in several States and by continuing the work there is no question that they can be completely obliterated from the United States in the course of a few years.

Tuberculosis is perhaps the disease which causes the heaviest losses to the live-stock industry. During the fiscal year 1908 there were found affected with tuberculosis 0.96 per cent of the adult cattle and 2.05 per cent of the hogs examined in the federal meat-inspection service. Taking these figures in connection with reports of the tuberculin test on dairy cattle, it is estimated that more than 1 per cent of beef cattle, 2 per cent of hogs, and about 10 per cent of dairy cattle in the United States are affected with tuberculosis.

A careful study was recently made, followed by an estimate of the economic loss from this disease, and it was found that the loss probably exceeds $14,000,000 a year. Some of the items making up this amount are the loss on animals found tuberculous in the meat inspection, the depreciation in the value of the stock of farm animals remaining alive, the decrease in the milk yield of tuberculous cows, the impairment of breeding qualities, the increased cost of wholesome meat and dairy products, and injury to the trade in live animals and meats.

The remedy seems to be to eradicate tuberculosis from the farm animals of the country, and this is believed to be entirely practicable, although it will necessarily be a large and costly undertaking. The expense, however, will unquestionably be justified by the results. It has been clearly shown that hogs readily contract tuberculosis from cattle and that diseased cattle are the primary source of the infection in hogs. The main problem, therefore, is to eradicate the disease in cattle.

Live-stock owners should be aroused to the danger of having tuberculosis among their animals and should be educated as to the nature of the disease and the best methods of combating it. Valuable work in this direction may be done by the general and agricultural press and by official publications, also by lectures at public gatherings, farmers' institutes, etc.

The real work of eradicating tuberculosis, however, must be done by the federal and state governments in cooperation. There should be a systematic effort to determine to what extent and in what localities the disease exists, and the tuberculin test should be applied to cattle in such sections. The safest way of disposing of infected animals is to slaughter them. In order to reduce the financial loss to a minimum and at the same time guard against the sale of unwholesome meat, animals should be slaughtered at abattoirs under federal or other competent veterinary inspection. In this way a large proportion may be safely passed for food and made to yield its full meat value, while only those animals whose meat may be dangerous to health will be condemned.

An effective means of locating and eradicating tuberculosis of live stock would be to establish by state legislation a system of tagging cows sent to market for slaughter from suspected districts, so that if any were found tuberculous in the meat inspection, they could be traced back to the place of origin, thus locating centers of infection. The Bureau of Animal Industry is already cooperating with the authorities of some States by reporting on tuberculous animals, and the results so far have been very encouraging. To give the plan general application authorities should be empowered by law to require that shippers shall tag their cows in such a way that they may be identified and their origin determined.

Inspectors should be stationed at important points for the purpose of testing cattle for breeding and dairy purposes, and each State that is endeavoring to eradicate the disease should require that no cattle for breeding or dairy purposes shall be admitted from outside the State unless they have passed the tuberculin test. A good method of preventing the spread of tuberculosis among breeding stock would be the establishment by the State of one or more free herds of breeding cattle for the use of stock raisers in the State, or the State could certify to the health of free herds.

As the eradication of tuberculosis is largely a public health measure, it is not only reasonable that the State should compensate at least in part the persons whose cattle are slaughtered, but it is absolutely essential if the cooperation of cattle owners is to be secured.

The agricultural appropriation act for the current fiscal year authorizes the Secretary of Agriculture to investigate the prevalence and extent of tuberculosis among dairy cattle in the United States, and steps are being taken by this bureau to collect such information. Before any effective or extensive work of eradication can be undertaken, however, larger appropriations will be necessary.

A recent compilation and study of state laws on the subject show that very few States have adequate laws for the protection of live stock from contagious diseases and for the control and eradication of such diseases. Furthermore, very few States have made anything like adequate appropriations for the necessary expenses of effective work. An essential step toward any comprehensive work dealing with such diseases will be the enactment of proper legislation by the various States where this is lacking, and the appropriation of sufficient funds to carry on the work.

SHRINKAGE IN ANIMAL PRODUCTS DUE TO INJURIOUS INSECTS.

By C. L. Marlatt,
Bureau of Entomology, U. S. Department of Agriculture.

All domestic animals suffer seriously from parasitic and other insects, and above the reduction in the annual output of products is the heavy loss occasioned by certain insect pests to such stored and manufactured animal products as hides and furs, and stored animal food products. There is also the very serious check on production caused by the prevalence of certain insect-borne diseases of domestic animals. This last source of loss, however, is taken up elsewhere.

The value to the farmer of all animal products for the year 1907 is given in the report of the Secretary of the United States Department of Agriculture for that year as $2,678,000,000. This represents the products actually sold or consumed, and not the stock animals. Beef and dairy and all other domestic animals, including poultry, are subject to the attacks of biting and parasitic insects which operate as a very considerable check on fattening or on the yield of salable products. In the case of cattle the principal culprits are the ox warble and various biting flies and ticks. The damage chargeable to the ox warble was very carefully investigated several years ago by a western farm paper, and from the averages reported from the chief cattle States of the Mississippi Valley it was shown that 50 per cent of the cattle received in the Union Stock Yards at Chicago during the grubby season (from January to June) were infested and more or less injured by the presence of the larvæ of this insect. The depreciation in the value of hides and the lessened quantity and poorer quality of the beef indicated a total loss during the season of over $3,000,000. This loss applies only to the cattle coming to the Chicago market during the period mentioned, and is merely an indication of the much greater loss to range and farm stock throughout the country from this one pest. The loss for Great Britain from the warble has been estimated to vary from $10,000,000 to $35,000,000 per annum, and the total for the United States certainly can not fall below that for Great Britain.

The shrinkage or check to fattening or lessening of milk production, due to the annoyance from biting flies and other insect pests of cattle, represents a very considerable total every year; probably, in view of the greater prevalence of these pests, much more than is chargeable to the ox warble.

The loss to cattle production and values due to ticks (particularly the southern cattle tick responsible for Texas or splenetic fever) is enormous from the standpoint of the disease mentioned. This phase of the question, however, falls under a different section. Nevertheless, merely as parasites, ticks are a very serious pest in the South, seriously affecting the health and productive capacity of cattle.

Horses, sheep, and other farm animals, including poultry, are subject to the attacks of similar parasites and other insect enemies, and if all these be considered, including, for example, the buffalo gnats, often very destructive in the South, the many gadflies, botflies, the screw-worm fly, and such parasites as ticks and lice, a heavy percentage of loss must be reckoned. A 10 per cent annual loss has been assigned, certainly a conservative estimate, which represents a shrinkage for 1907 of $267,000,000 in value of animal products due to insect pests.

CONTROL OF INSECT ENEMIES OF LIVE STOCK.

A very large percentage of the loss to animal products from insect attack can be saved by the more general adoption of known remedies, but many of the problems are still under investigation. The tick problem is being actively investigated, and a rather simple method of rotation of pasturages seems to offer a practical means of control, and, under favorable conditions, of absolute extermination. A knowledge of the life history of biting flies and various internal parasites makes it possible to control these pests also in a considerable measure by limiting their breeding places and protecting cattle by the use of repellant washes or lotions. Such parasites as ticks and lice can also be controlled by intelligent quarantining.

THE PUBLIC RANGE.

By A. F. Potter,
United States Forest Service.

GENERAL DESCRIPTION.

There is no other natural resource of the country in which the people at large are more directly interested than in the use of the forage crop which grows upon the public lands. That there is a vast amount of land not at present susceptible of cultivation and so located that it can not be reclaimed by irrigation, which, for at least a long time to come, will be valuable only for grazing purposes, is a well-established fact.

The area of this land is probably not less than 300,000,000 acres, and includes parts of all the Western States. There is also a large area of partially wooded land, some of which has been included within the national forests, the principal agricultural value of which at present is for grazing live stock. In addition there is also land which can be reclaimed by irrigation, and a limited area upon which crops can be grown under favorable climatic conditions through dry farming, but which in the meantime is used only for grazing.

Most of this land has been occupied for many years by the stockmen of the West with their cattle, horses, sheep, and goats, and a large portion of the supply of beef, mutton, and wool furnished the markets of the United States has come from the herds and flocks grazed upon these public lands.

The use of the public lands, excepting such areas as have been withdrawn for national parks, national forests, military reservations, or other like public purposes, has always been free and unrestricted. This was a great advantage to the settlers on the frontier, and resulted in the establishment of many homes in localities where the lands were valuable only for grazing, but, on the other hand, it has resulted in serious abuse of the lands by persons who engaged in the live-stock business upon a speculative basis.

A very large proportion of the annual crop of grasses and forage plants can not be cut and kept for future use, but must be harvested by driving the live stock to the grazing grounds and allowing them to feed upon it. In this way the forage crop is converted into a marketable product, which adds very greatly to the general prosperity of the people and to the wealth of the nation.

The stockmen are thus enabled to make profitable use of the products of a very large area of foothills, plains, and desert lands which otherwise would go to waste. It is plain, then, that grazing is not only a source of prosperity under ordinary circumstances, as a close companion to agriculture, but is also one of the most important means of producing revenue from lands that are outside of the limits of profitable cultivation.

In the western range country stockmen have been among the earliest pioneers, and grazing has been the means of opening the way to other pursuits, because the herdsman with his cattle, horses, and sheep took possession of the frontier and opened up the way for tillers of the soil.

The evolution of the western range from grazing to cultivated land is brought about largely in the following manner: A portion of the range is fenced in order that the stock may be kept under control. The stockman prospects around for water, cleans out and improves the flow of springs, and finds places where water can be had by digging wells. Having succeeded in getting his pasture sufficiently watered for grazing purposes, he then gives his attention to seeing what can be done in the way of raising winter feed. Portions of the best land are set aside for cutting wild hay and experiments are made in raising cultivated forage crops. Where there is sufficient water for irrigation, the land is usually seeded with alfalfa, and immediately furnishes an increased amount of forage. The result is that it is soon found that the grazing capacity of the area has increased and the quality of the stock improved. This attracts the attention of others, and soon new divisions of the range are made. Settlers are attracted by the success of the stockmen in raising winter feed for their stock and try more varied farming. Thus the country changes to a more thickly settled and prosperous condition, and the successful establishment of homes is made possible upon the range lands.

On July 1, 1906, the total area of vacant public land was 418,358,752 acres. During the past ten years the average amount of public land disposed of annually has been about 18,000,000 acres. About two-thirds of the entries have been made under the homestead act. At this rate it will only be a few years until all of the land suitable for cultivation will have passed into private ownership. This does not mean that a less number of stock will be raised, but that a greater proportion of the animals will be fed upon the products of the cultivated lands, and that the need for an economic use of the remaining vacant lands will be increased proportionately, because in many instances the stock must be pastured on outside range during the growing period of the cultivated crop.

In reply to the questions asked in a circular sent out by the National Conservation Commission, 35 per cent of the stockmen heard from stated that they fed all of their stock upon the products of cultivated lands during the winter season, 35 per cent stated that they fed at least a portion of their stock during the winter, while only 30 per cent of the whole number reported that all their stock were pastured upon the open range during the entire year. This shows very plainly the close connection between grazing and agriculture, and indicates that beyond a doubt the practice of winter feeding is being adopted in many localities. The result will be to decrease the winter losses and place the live-stock industry on a much safer basis.

CAUSES OF DECREASE IN GRAZING VALUE.

At first, when the public lands were used only by the pioneers with their small bands of stock, there was an abundance of range for all and no one gave any thought to the future, but it was not long before men from the more thickly settled sections of country, where the ranges were becoming crowded, commenced to move westward in search of better opportunities, and gradually the range became more and more crowded.

The first effect of this was that the stock did not fatten as in former years, and consequently did not bring as good prices when marketed. Then, on account of the stock being in poorer flesh, the winter losses commenced to become greater and the percentage of natural increase smaller.

In localities where overstocking continued the grasses and forage plants were gradually trampled out until in many sections the grazing value of the lands was almost entirely destroyed. This was naturally followed by very serious losses of stock, particularly in seasons of drought.

The damage has not been done by any one kind of stock, but by all during different periods or in different localities. In the early eighties there was a great boom in the cattle business, and immense herds were driven to the ranges of the Southwest. It was only deemed necessary to secure a few watering places before turning loose unlimited numbers of stock upon the open range. There was no law to prevent overcrowding or to authorize any control whatever over the use of the lands. Under this condition of affairs it was not long until serious contentions arose, and out of it grew the notorious Lincoln County war in New Mexico and the Tonto Basin war in Arizona, both of which resulted in serious loss of life and property. While all of this was going on the carrying capacity of the range was gradually being diminished by grazing excessive numbers of stock, so that when in the early nineties there was a serious drought, the forage crop was entirely inadequate to support the number of animals, and a very large percentage died from starvation. At this same time the market prices for cattle and horses declined very greatly and many of the stockmen were compelled to close out their business through inability to make any profit or to meet their indebtedness. During this period the prices of sheep were also very low, but in the late nineties prices of wool and mutton began to improve, and many of those who had formerly raised cattle and horses engaged in the sheep business. The era of prosperity in sheep raising has continued up to the present time, and there is still a very great demand for the use of range by this kind of stock. The fact that sheep are herded has given their owners a great advantage on the open range, as herds are easily moved to localities where the feed is best or where there is available range.

There has been much complaint regarding the crowding in of sheep on ranges claimed by the cattlemen, and in many cases there has been serious conflict. In some localities the cattle owners through organized action have succeeded in keeping sheep off the ranges used by their cattle, but it is generally admitted that the increase in the number of sheep has compelled many of the smaller owners to discontinue raising cattle and to seek some other means of making a livelihood.

In such localities, and in many localities where no opposition was offered by the cattlemen, the number of sheep has increased until in the competition for range there has been very little regard for the interests of the public, and it has become a constant race from place to place in search of the most favorable feeding grounds.

The lack of control in the use of these lands has resulted in overgrazing and the ruin of vast areas of otherwise valuable range.

In response to a circular sent out by the Public Lands Commission in 1904, requesting information regarding the condition of the public-grazing lands, 80 per cent of the stockmen heard from reported the carrying capacity of the ranges they were using to have diminished, and 80 per cent of those making such report attributed the decrease to overstocking. Practically the same results have been obtained from a circular sent out this year by the National Conservation Commission, and, therefore, it is evidently a well-established fact that damage to the public-grazing lands is due almost entirely to the lack of any system or authority for its control.

METHODS FOR IMPROVEMENT OF GRAZING LANDS.

The most general method adopted by stockmen to control the use of public grazing lands has been through securing title to the watering places. If all of the water on a range could be secured, this has usually been recognized as giving the owner a right to the use of adjoining lands for grazing purposes, because in case of controversy he could fence up the water and thus prevent stock other than his own from using the outside lands.

However, the cases in which very large areas have been controlled in this way are exceptional, and as a rule it has only been successful as a means of securing the exclusive use of comparatively limited areas.

The most practicable method of controlling the grazing of stock is by fencing the lands into pastures. It has been found that wherever the lands were protected by fencing and overstocking stopped, the condition of the range at once improved and the amount of forage increased; better care is taken of the stock; losses from straying and death are lessened; a better grade of stock is raised, and in every way a better use of the land is obtained. Recent experiments made by the Forest Service in the use of fenced lands for the summer grazing of sheep have proven conclusively that they will carry 50 per cent more stock and at the same time produce better animals than are raised on the open range where the stock must be herded. Lambs raised in an experimental pasture in the State of Oregon weighed 10 pounds more than the same age and grade of lambs raised on the outside range.

In all of the Western States it is universally true that steers which are pastured on range controlled by fences outweigh steers from the open range and bring better prices on the market.

Experience in the management of grazing upon the national forests shows that upon ranges which were overgrazed prior to the enforcement of proper regulations a very large percentage of the forage is wasted through stock entering upon the range too early in the season, while the feed is immature. In the absence of any restriction there is always a race for feed in the early part of the season, each stockman trying to get upon the summer range first, in order to establish camps and hold the range. The serious damage caused by trampling is immediately stopped when the stock is kept off until the feed has a chance to get fairly started. In fixing the periods during which stock are allowed to graze within the forests, an endeavor is made to meet local conditions as nearly as possible and to allow the use of each district during the period when it is most needed and can be used to the best advantage.

By dividing the ranges into separate grazing districts and allowing the use of the lands by the kind of stock for which it is best adapted and during a proper grazing period, an increase of at least one-third has been made in the amount of forage utilized. Last year is was possible to increase the number of stock grazed upon 30 of the national forests on account of the improvement in the condition of the range which had been brought about by proper regulation.

In the answers which were received to the circular sent out by the Public Lands Commission in 1904, 15 per cent of those reporting improvement in the condition of their range attributed it to national forest regulation. Of the stockmen who, in response to the circular sent out by the National Conservation Commission this year, reported an increased amount of forage upon their ranges, 25 per cent credited the improvement to national forest regulation. This is a very satisfactory showing of the practical results which have been obtained and indicates that without doubt rapid advancement is being made in restoring the former grazing value of the lands.

Throughout the western range country the market for hay and other products of irrigated land depends very largely upon feeding live stock. In many places remote from transportation farming is only made profitable through raising live stock to consume the products of the farm. Cattle and sheep which are pastured in the mountains during the summer are driven to the fields in the fall after the crops have been harvested, and there fed during the winter.

As new areas are reclaimed and brought under cultivation by the Government and by private enterprise, the proper use of grazing lands in their vicinity becomes a matter of very great importance, because if the lands forming the watersheds of the streams are abused by overgrazing or improper grazing, then the water supply is diminished and, if the lands are not used for grazing, then the most profitable means of marketing the products of the land is removed.

The solution of this problem lies in the control of grazing upon the public lands and the enforcement of such regulations as are necessary to insure their permanent use for grazing purposes.

THE PUBLIC RANGE.

By A. D. Melvin,
Chief of Bureau of Animal Industry, U. S. Department of Agriculture.

From personal observation and from reports received from inspectors, there is no doubt that on the whole the carrying capacity of the public range has decreased.

This decrease is due to (1) the taking up of the public range by homesteaders, and (2) overstocking and misuse. The ranges have been overcrowded, especially at certain seasons and in the vicinity of watering places, and close grazing and trampling have in some places almost exterminated the native grass.

Measures should be taken to prevent overstocking and to protect the range so that the supply of grass may be renewed. There should be some system of government regulation of grazing on the public range. This could probably be best accomplished by leasing the range to stock owners and allowing them to fence the land. By this means the range would be brought under definite proprietorship, the lessees exercising control over the land and regulating the number of animals, which would encourage them to make improvements aiding in the conservation of both live stock and range. Such a plan would also assist in the control of contagious diseases and in the protection of live stock during the winter, two matters which are practically impossible of accomplishment on the open range under present conditions.

Reseeding the range where the natural grass has been destroyed would also be advantageous.

SWAMP AND OVERFLOW LANDS.

By Robert Follansbee,
United States Geological Survey.

INTRODUCTION.

The following report has been prepared in response to an inquiry from the National Conservation Commission regarding the area and ownership of the swamp lands of the United States, together with the cost and present status of reclaiming them.

In giving general estimates of swamp areas in the various States, the report of Prof. N. S. Shaler, published in the Tenth Annual Report of the United States Geological Survey, was used as a basis. The figures were modified, however, as further investigation showed them to be in error, or where subsequent reclamation work has changed their value.

The data regarding the present ownership have been derived mainly from the secretaries of state for the various States.

As the cost of reclaiming the swamp areas has varied widely, no attempt has been made to generalize, but instead typical examples in different sections of the country have been described as far as possible. These can be used as a basis for estimating the cost of future work. The data as presented were obtained for the most part from engineers and landowners directly interested, and should therefore be reliable within the limits noted elsewhere.

The data regarding the present status of the work have been compiled from various sources, mainly through the technical press and through correspondence.

ESTIMATE OF SWAMP AND OVERFLOW AREAS.

As noted in the introduction, the basis for the estimate of swamp areas in each State was Professor Shaler's report on swamps. His estimates have been modified either where a sufficiently large percentage of a State has been topographically mapped to show that such a change is necessary, or where information acquired by a personal visit to the State has shown them to be in error.

Wherever possible an attempt has been made to differentiate between permanent swamp and land periodically overflowed to such an extent as to render cultivation hazardous. But as Professor Shaler made no such distinction, it is not possible at present to separate the two types in the majority of cases. Also where the estimates were based on the topographic sheets they do not include the overflow lands, but it is believed there is not a great amount of land seriously overflowed in those States, with the possible exception of New Jersey and Oklahoma. Accompanying each estimate is a statement regarding its source, in order that some idea may be formed regarding its accuracy.

Swamp and overflow areas.

State.	Area (acres).	Authority.
Alabama	1,120,000	Shaler.
Arkansas	5,760,000	Do.
California	1,850,000	The area in Sacramento Valley was measured from a map of that section issued by the State in 1906, while the remainder of the area was obtained from the Land Office map.
Connecticut	37,700	State entirely mapped topographically, and estimate obtained by direct measurement.
Delaware	200,000	38 per cent of estimated swamp area mapped. Remainder uncertain.
Florida	18,560,000	Shaler.
Georgia	2,400,000	Do.
Illinois	2,688,000	This represents overflow areas along the streams as given by the State Geological Survey. It is estimated that 90 per cent of this area is either wholly or inadequately protected against floods, but if protection were afforded $150,000,000 would be added to the farm values of the State. The uplands are practically drained.
Indiana	1,000,000	This includes 600,000 acres of overflow land along the Wabash, West Fork of White, and Ohio rivers where levee protection is needed. Estimated from direct measurement of map compiled in field by writer. The remainder of the swamp area is found principally along Kankakee River, as most of the uplands are drained.
Iowa	800,000	Estimate based on the writer's knowledge of general conditions in the State. Areas found chiefly in north-central part and on Missouri slope. Drainage is progressing so rapidly that estimates must be revised frequently.
Kansas	160,000	Shaler.
Kentucky	224,000	Do.
Louisiana	9,600,000	Do.
Maine	240,000	The average swamp area per square mile for New York, New Hampshire, and Vermont was taken as the area per square mile for Maine.
Maryland	356,000	Swamp area practically mapped. Estimated from direct measurement.
Massachusetts	138,700	State entirely mapped topographically. Estimated from direct measurement.
Michigan	4,400,000	Shaler's estimate reduced somewhat to allow for land already drained.
Minnesota	4,500,000	Estimate based on Shaler. State has received 4,500,000 acres under swamp act. State drainage engineer estimates that there were 10,000,000 acres too wet for agriculture, of which 3,000,000 acres have been drained.
Mississippi	6,173,000	State Geological Survey.
Missouri	1,920,000	Shaler. Area chiefly in southeastern part of State.
Nebraska	256,000	Shaler.
New Hampshire	43,000	30 per cent of State mapped topographically. Assuming same ratio of fresh marsh to dry land mapped to hold true for entire State gives 37,400, or 43,000 acres of both fresh and salt marsh.
New Jersey	601,900	State entirely mapped. Estimated from direct measurement.
New York	576,000	81 per cent of swamp area mapped topographically.
North Carolina	2,400,000	Shaler.
North Dakota	226,000	Do.
Ohio	200,000	Based on writer's knowledge of general conditions.
Oklahoma	35,000	Includes Indian Territory. Swamp area practically mapped. Estimated from direct measurement.
Oregon	500,000	48 per cent of swamp area mapped. Remainder of area obtained from Land Office map.
Pennsylvania	96,000	52 per cent of swamp area mapped. Remainder of area somewhat uncertain.
Rhode Island	17,900	State entirely mapped. Estimated from direct measurement.
South Carolina	1,760,000	Shaler.
South Dakota	226,000	Do.
Tennessee	800,000	Do.
Texas	1,620,000	Do.
Vermont	70,000	Of area of State, 39 per cent mapped topographically. Estimate based on assumption that ratio of swamp to total area mapped applied to entire State.
Virginia	384,000	60 per cent of swamp area mapped. Remainder estimated from knowledge of general conditions.
Washington	75,000	52 per cent of swamp area mapped. Remainder of area uncertain.
West Virginia	2,500	State entirely mapped. Estimated from direct measurement.
Wisconsin	2,500,000	Shaler's estimate reduced somewhat to allow for land already drained.
Wyoming	25,000	Swamp area practically all mapped. Estimated from direct measurement. This is exclusive of Yellowstone National Park.
Total	74,541,700	

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OWNERSHIP.

Under the swamp act of 1850 practically all the public swamp lands have been donated to the States in which they are located, with the proviso that the funds derived from their sale shall be used to reclaim them. As a result, not more than 1,300,000 acres, approximately, remained as public lands June 30, 1907 (see Land Office circular on unappropriated lands). Such lands were donated only to the States existing in 1850, not to those thereafter admitted. These lands were located as follows:

	Acres.
Alabama	5,000
Arkansas	17,000
Florida	78,900
Louisiana	4,600
Minnesota (approximately)	1,200,000
Wisconsin	2,200
Total	1,307,700

This is approximately 1.7 per cent of the entire swamp area of the country.

The Commissioner of the Land Office for 1907 gave the following summary of swamp-land claims that had been approved:

Swamp-land claims approved and certified under various grants.

State.	Claims approved—total since dates of grant.	State.	Claims approved—total since dates of grant.
	Acres.		*Acres.*
Alabama	419,325.76	Minnesota	4,533,588.77
Arkansas	7,695,637.26	Mississippi	3,341,057.98
California	2,078,444.93	Missouri	4,498,573.28
Florida	20,458,866.46	Ohio	26,271.95
Illinois	1,497,028.35	Oregon	355,749.62
Indiana	1,266,075.75	Wisconsin	3,353,067.86
Iowa	942,180.67		
Louisiana	9,385,026.27	Total	65,582,503.50
Michigan	5,731,608.68		

The following table shows the amount of swamp lands still owned by the States, and also what disposal has been made of the remainder:

State ownership of swamp lands and method of disposing of remainder.

State.	Owned by State.	Disposal of remainder.
Alabama	0	State granted lands to trustees of Alabama insane hospitals.
Arkansas	200	
California	0	Practically all held in private ownership.
Connecticut [a]	0	Lands held in private ownership.
Florida	2,640,000	9,230,000 acres granted to private parties, canals, etc.; 8,230,000 acres granted to railroads.
Georgia	0	Practically all held in private ownership.
Illinois	0	State conveyed lands to counties, which sold them to individuals.
Indiana	0	Practically all held in private ownership.
Iowa	0	State conveyed lands to counties, which sold them to individuals.
Louisiana	0	State conveyed lands to various levee boards, which sold them to individuals.
Michigan	9,500	Remainder sold to individuals and proceeds of a part spent in reclamation work. The rest were disposed of under state homestead laws.
Minnesota	2,500,000	Remainder sold to individuals.
Mississippi	10,000	Remainder sold or donated to commissions for the improvement of certain rivers.
Missouri	0	Prior to 1869 some lands patented to individuals, but after that date the lands were conveyed to the counties.
New Jersey [a]	100	Remainder held in private ownership.
New York [a]	100	Do.
North Carolina [a]	230,000	These lands are owned by the state department of education. The remainder of the swamp lands are held in private ownership.
Ohio	0	Practically all held in private ownership.
Oregon	1,000	
South Carolina [a]	0	Lands granted to individuals.
Texas [a]	....	(No data.)
Virginia [a]	0	Practically all held in private ownership.
Wisconsin	50,000	2,000,000 acres sold for benefit of normal school fund. Remainder sold for benefit of general fund. The lands still owned by the State have recently been appropriated for a forest reserve.

[a] States did not receive lands under swamp act. In the States omitted from the above list the swamp areas are small and are chiefly owned by individuals.

COST AND RESULT OF RECLAIMING SWAMP LANDS.

The cost of reclaiming the swamp lands in the United States has varied so widely that no attempt will be made to reach general conclusions on the subject. Instead, typical examples in different parts of the country will be given in order that a basis may be formed for estimating the cost of future work.

With regard to the manner of reclamation, wet lands may be divided into two classes—(1) those requiring protection by levees from periodical overflows, with additional interior drainage; and (2) those that are wet the most of the year owing to defective natural drainage. This latter type is found not only along the rivers, but also on the uplands and frequently on divides. It comprises the greater part of the wet land and is, fortunately, capable of being reclaimed at less expense than the other type, and with less uncertainty regarding the success of the project. Usually all that is needed to drain swamps of this type is improvement of the natural drainage lines and the addition of artificial channels sufficiently large to take care of the run-off during the wet seasons.

The reclamation of wet lands of the overflow type involves a study of the rivers causing the overflow before protective measures can be undertaken intelligently. It is necessary to have records of flow extending over a series of years in order that the maximum discharge can be determined. When this is known, it is necessary to build levees of sufficient height and strength to withstand this maximum flow. As the building of the levees closes the natural drainage channels of the land protected, it is also necessary to construct artificial channels which lead either to reservoirs from which the run-off is pumped during high water or else to the lower end of the district, which is left open. Therefore it is easily seen that the reclamation of lands of this type involves greater expense and a higher order of engineering ability.

It is difficult to determine the actual cost of reclaiming the wet areas in the past, as much of the work done was inadequate to drain the lands properly and consequently further work was necessary to complete the drainage, and, as this work was done in a haphazard way, the total expense was greater than it should have been. Again, many of the drainage ditches have not been properly kept up, so it is difficult to say whether the cost given represents the complete reclamation of the land. The same thing is true of the levee systems. In the lower Mississippi Valley it is customary to leave the lower end of the districts open so that the interior drainage may have a gravity outlet, but in the upper valley, where the areas are much smaller, the districts are entirely closed, making pumping necessary during certain seasons, to properly care for the interior drainage and upland drainage adjacent. As many of the northern districts have either no pumping plants or inadequate ones, the result is that during periods of high water the protected land is more or less wet and so reclamation can not be considered complete. In the reclamation of both types of swamp, small yearly charges for maintenance are necessary in addition to the first cost.

With the foregoing limitations, examples of cost and result are given, which were obtained for the most part from engineers and landowners directly interested.

WET LANDS DUE TO DEFECTIVE NATURAL DRAINAGE.

Indiana.—Twenty-three thousand acres have been reclaimed in Morgan County at a cost of $4 per acre.

In 1900 a tract of 7,200 acres, adjacent to Kankakee River in La Porte County, was bought for $21 per acre. The cost of straightening the river channel and to tile draining brought the cost up to $55. The land is now selling for $100 and upward. As the Kankakee channel was not enlarged sufficiently to care for the maximum discharge, the land is overflowed in the spring and hence reclamation can not be considered complete.

Illinois.—In 1885, 35,000 acres of land in Mason and Tazewell counties were drained. Previous to drainage the land was worth $10 to $15 per acre, and eighteen months after the ditches were completed it was worth $50 to $60.

Three thousand five hundred acres have been drained in Champaign County at a cost of $5 per acre, with an increase in value of $75 for land fully reclaimed and $5 to $25 for partially reclaimed land.

In Whiteside County 28,000 acres have been drained at an average cost of $7 per acre, with an increase in value of $25 to $50.

In Bureau and Henry counties 33,000 acres have recently been reclaimed at a total cost of $420,000, or an average cost of $13 per acre. The 33,000 acres comprised land varying from permanent swamp to land wet only during rainy seasons. The swamp comprised one-fourth of the area and was assessed $10 per acre. This swamp land had no agricultural value, but was held at $25 for speculative purposes. The increase in value has been $30, exclusive of the cost of reclamation.

J. A. Harman, an Illinois engineer of wide experience in drainage, states:

> The cost of drainage of Illinois lands has varied greatly. On the flat prairie lands, where no water is to be cared for except that which falls directly upon the lands in the drainage district, from $3 to $5 per acre has been found sufficient to provide a drainage system of main ditches and $6 to $12 per acre additional for complete tile drainage. Where it is necessary to straighten streams of any considerable magnitude the cost ranges from $10 to $20.

Minnesota.—The state drainage engineer states that 3,000,000 acres have been drained in Minnesota at an average cost of $1.50 per acre, exclusive of tile drainage, which would cost $6 to $10 per acre additional. He cites an instance where land was drained in 1906, and in 1908 produced celery which gave a net return of $1,500 per acre.

Iowa.—Twenty-two thousand acres in Calhoun County were partially drained at a cost of $3 per acre, with the result of doubling the value of the land.

New York.—Thirty thousand acres in Conawango swamp were drained at a cost of $2.50 per acre. Previous to drainage the land was worth from $2 to $5, but after drainage was valued at $30 and upward.

South Carolina.—The sanitary and drainage commission of Charleston County reclaimed 75,000 acres of swamp in that county at a cost of approximately $1.50 per acre. The Secretary of the commission, Hon. James Cosgrove, states that the land was assessed at $2 per acre prior to drainage, but has now increased so in value that some of it is held at $250 per acre. Regarding the improvement to health, he quotes a letter from the A. C. Truxbury Lumber Company, as follows:

> We are in receipt of your letter of the 16th instant asking for our experience relative to the health of our employees, and in reply we wish to say that when we first decided to locate in Charleston and were looking for a site we were informed that the property adjoining Horlbeck's woods was considered very unhealthy, but we had faith in the work of the drainage commission and decided to erect our plant at that place. This section had always been unhealthy, so much so that it was impossible for the people to live in the vicinity. One of the first buildings which was erected was a large 20-room hotel, which was built in 1905 and has since been fully occupied by our employees, many of whom came from a different part of the country and were therefore unacclimated, but we have yet to hear of the first case of malaria at the hotel. This is also the case with all of our employees, and we are satisfied that this section is now as healthy as any in the country.

LANDS SUBJECT TO PERIODICAL OVERFLOW.

Cost for reclaiming lands of this type can be given only for the upper Mississippi Valley region, as investigations have not yet been made in the Southern States.

The result of leveeing the lands along the upper Mississippi has been to increase the value from $5 to $15 for unprotected lands to $70 to $100 for lands properly leveed and drained.

Reclaimed overflow lands on upper Mississippi River.

District.	Area.	Cost per acre.	Remarks.
	Acres.		
Drury	5,700	$18	Includes pumping plant.
Egyptian	11,000	18	No pumping plant.
Sny Island	110,000	20	No pumping plant needed.
South River	10,000	20	No pumping plant.

Along the Illinois River unprotected bottom land is worth $5 to $15, while fully reclaimed land sells for $100 and upward. Much of the land is leveed, but is not properly provided with an interior drainage system. Such land sells for $35 to $60.

Reclaimed overflow lands on Illinois River.

District.	Area.	Cost per acre.	Remarks.
	Acres.		
Big Swan	12,000	$18	No pumping plant.
Hillview	12,500	25	Includes pumping plant.
Nutwood	11,000	25	No pumping plant.
Partridge	3,000	30	Includes pumping plant.
Spring Lake	12,500	20	No pumping plant.

Mr. J. A. Harman, who was quoted previously, states:

> Along the Illinois River where it is necessary to construct levees which will average from 12 to 15 feet high, drainage ditches, and pumping plants, the cost varies from $20 per acre to $50 per acre for the leeves, main drainage system, and pumping plant. In no case so far has the cost been found prohibitive; in other words, these lands, which are subject to overflow and now have no productive value, but a speculative value of $5 to $25 per acre, can well afford a drainage tax of even as much as $50 per acre, because when drained they will have a productive value equal to the best land in the Mississippi Valley.

Indiana.—The O. P. D. levee opposite Newport protects 1,400 acres of land from the Wabash overflow at a cost of $20 per acre. There is no pumping plant.

In Sullivan County land that was worth $5 to $10 before leveeing is now worth $15 to $100 per acre.

COST OF FUTURE RECLAMATION.

As the reclamation of wet lands has been shown to involve inexpensive engineering work mainly, there is no reason to doubt that the greater part of the swamp and overflow lands in the country can be reclaimed at comparatively small cost per acre. Whether the character of the soil in all cases will warrant the expense can be determined only by further investigation, but the results already accomplished show that as a rule the wet lands are exceedingly fertile.

Whether the future cost of reclamation will be substantially the same as in the past, or whether it will be less, will depend largely upon the manner of doing the work. Especially is this true regarding the overflow lands. If these lands are reclaimed by the owners of different tracts acting independently of one another and reclaiming only comparatively small tracts at a time, with a possible result that protection to one section may make conditions worse in another, there is no reason to suppose that the final cost will be lessened except as methods and machinery are improved. But if the land along a river can be treated as a unit, the work can unquestionably be done more efficiently and cheaply.

In southwestern Indiana a preliminary report was made regarding the leveeing of 91,000 acres of Wabash River overflow, and it was estimated that the cost would be $8 per acre.

In Iowa drainage is being pushed very rapidly by means of drainage districts organized under state laws, whereby the land is assessed according to the benefits derived. In these districts the maximum assessments range from $3 to $11 per acre in the various districts.

In southeastern Missouri it is estimated that 500,000 acres of swamp and overflow land can be reclaimed at a cost of $10 per acre.

Mr. J. F. Le Baron, consulting civil engineer, after making preliminary surveys of the delta lands of Louisiana for the purpose of reclaiming them for rice culture, states (Trans. Am. Soc. Civ. Eng., vol. 54):

> If this land should be taken in single sections and it should be necessary to bring the water in a long flume and pump also, with a reservoir, the cost would be $16.50 per acre, while on the other hand in those locations where no pumping would be necessary, but the land could be flooded and drained by the action of the tide, the cost would be only $2.41 per acre. Each of these cases can occur on these lands.
>
> As to the income, the opinion is unanimous among all in that district with whom the writer has conversed that these reclaimed lands would rent easily and quickly for $5 per acre up to $14, with water supplied, paid in rice.
>
> These delta lands are so much richer than the prairie lands that, measured by their productiveness, they should easily bring twice as much, to say nothing of their immediate proximity to the metropolis of the State. There is no doubt they would be worth $200 to $300 per acre for truck farming when reclaimed, as some of these lands are only 3 miles from the center of the city of New Orleans, with a population of about 340,000.

PRESENT STATUS OF DRAINAGE.

While drainage work has been carried on for years in the upper Mississippi Valley, with the result that many hundred thousand acres in that section have been drained and are now among the richest farm lands, most of the other sections of the country have seriously considered the problem only within the past few years. The most feasible method of procedure has been the organizing of drainage districts by the landowners, under the state laws, with authority to raise funds by issuing bonds secured by the lands benefited. In this way the greater part of the land has been reclaimed.

Following is a brief account of the present status of drainage in each State:

Alabama.—Practically no work is being done in this State.

Arkansas.—Considerable work is being done in St. Francis Basin and in the southwestern part of the State.

California.—The most serious problem is the reclamation of the Sacramento Valley. In this section of the State, where the soil is extremely fertile, there are approximately 1,000,000 acres of swamp land, which may be increased in years of excessive high water. For years the landowners, assisted to some extent by the State, either through district organizations or by individual effort, have endeavored to levee the Sacramento River. These projects have been undertaken independently of one another, with the result that leveeing one section of the river, particularly in the lower region, has frequently made conditions worse in another section. It is estimated that vast sums, possibly reaching $20,000,000, have been spent chiefly by the landowners in river improvement and drainage work. Owing to the great amount of mining débris or detritus that is brought down by the Feather River into the Sacramento the river bed of the latter is constantly being built up, with the accompanying effect of lowering the levees.

In 1904 and 1907 the high water flooded several of the best levees of this district and did an immense amount of damage. The latter flood holds the record as to both height of water and damage done. The loss has been estimated at $5,000,000, most of which was on account of the damage to growing crops along the lower reaches of the San Joaquin and Sacramento rivers.

After the 1904 flood a state convention was called to consider the question, and a permanent organization, known as the "River Improvement and Drainage Association of California," was perfected. Through the efforts of this association many valuable data in regard to flood problems have been collected. A board was also organized consisting of three army engineers and the state engineer, which made a careful study of the situation, resulting in a federal appropriation for a detailed survey and report. This survey is being made at the present time by the army engineers. In addition to the above the State is cooperating with the United States Geological Survey in making detail topographic maps of the Sacramento Valley, and is also cooperating in the collection of run-off data. The Sacramento River being navigable, the Federal Government has done a large amount of dredging in an endeavor to maintain a navigable channel.

Florida.—The State has created a drainage district embracing most of the Everglades, and by imposing an annual tax of 5 cents per acre has created a fund with which to reclaim the land. At present there are two dredges at work cutting channels inland from the Atlantic Ocean. No other work of any size is being done in the State.

Georgia.—Attempts were made about 1894 to drain Okefinokee Swamp, but were abandoned before completion. No work is being done at present.

Drainage has been carried on actively for years, resulting in the drainage has been carried on actively for years, resulting in the drainage of practically all the upland marshes. The work remaining is chiefly protection against river overflow.

Illinois.—The last general assembly of Illinois made a small appropriation for the beginning of surveys and studies of the overflow lands of the State, for the purpose of acquiring a knowledge of the existing conditions and the methods by which the needed improvements may best be made. In accordance with this legislation, the State Geological Survey last year began the topographic mapping of portions of the Kaskaskia, Big Muddy, and Embarras rivers, in which it cooperated with the United States Geological Survey. As a result of this cooperation a topographic map on a scale of 2,000 feet to the inch, with a contour interval of 5 feet, is being made of important sections of these streams, the larger part of the work being carried on in the Kaskaskia River valley, the map of which is now practically completed from Shelbyville to the mouth of the river.

Indiana.—As in Illinois, drainage work has been carried on in Indiana for years, resulting in the drainage of the upland marshes. The work remaining is chiefly protection against the overflow of Wabash, White, and Kankakee rivers, but practically nothing is being done. Along the Kankakee River the problem has changed from that of draining marsh lands to protection against overflow.

Iowa.—Although drainage has not been carried on as long in Iowa as in Illinois and Indiana, it is being pushed very rapidly at present, with the result that the swamp lands are being rapidly drained.

Louisiana.—Beyond building levees along the Mississippi, little work has been done until recently. Now, however, a number of individuals have acquired large tracts of swamp land and are actively pushing the work of reclamation. The Manufacturers Record of June 18, 1908, describes approximately 320,000 acres that are being reclaimed.

Michigan.—In the Southern Peninsula drainage is being actively carried on, with the result that thousands of acres of the richest land have been reclaimed. The Northern Peninsula, however, is still heavily wooded, and until cleared there will be little drainage work undertaken.

Minnesota.—The State owns approximately 2,500,000 acres of wet land, for the drainage of which the legislature has appropriated $50,000 per year, and created a drainage commission, consisting of the governor, state auditor, and secretary of state. Up to 1906 the State had spent $317,000. The owners of the remainder of the swamps are actively engaged in draining them, with the result that the state drainage engineer estimates that all the lands will be drained in fifteen years at the present rate of progress. Provision was made by the Nelson Act of 1889 for the settlement by homesteaders of the ceded Chippewa lands of northern Minnesota, comprising an area of over 5,000 square miles. The settlement of these lands ceased immediately after the occupation of the high portions, as the remainder was almost entirely swamp. Congress on June 21, 1906, authorized the Secretary of the Interior to make a drainage survey of the lands in this area which remained unsold and which were wet or swampy in character, with a view to determining what portion thereof might be profitably and economically reclaimed by drainage. This survey has just been completed under the direction of the Director of the United States Geological Survey, and the results will be reported to Congress during the winter. The report for the Mud Lake district within this area has been completed and is included in Document 607, House of Representatives, Fifty-ninth Congress, second session, and is in sufficient detail to permit immediate construction work should Congress consider this step advisable.

Mississippi.—The levee along the Mississippi River is now practically completed. It is estimated that within the next two years this great work will be accomplished and will prevent in the future all overflows of the Yazoo Delta from this source. There is great activity in various sections of the State looking to the drainage of the very fertile delta lands. An act was passed by the legislature of the State on March 2, 1908, creating the Tallahatchie drainage district, incorporating the Tallahatchie drainage commission, and authorizing the governor to appoint the members thereof. This commission was given the right of eminent domain and empowered to issue bonds, levy and collect taxes for drainage construction, and enter into cooperation with the United States Government for making topographic surveys and maps of said district. Cooperation between the governor of Mississippi, the Tallahatchie drainage commission, and the United States Geological Survey was entered into on June 15, 1908, for the topographic mapping of this area on the scale of 2,000 feet to the inch, with a contour interval of 5 feet. Since that time active work has been in progress and about 40 per cent of the estimated area of the district (1,800 square miles) has been completed.

Missouri.—A drainage district has been formed to reclaim 500,000 acres of land in the southeastern part of the State. Preliminary surveys have been made, and from these it is estimated that the cost will be $5,000,000. Considerable work is being done by landowners to protect lands from overflow along the Grand, Marais des Cygnes, Tarkio, and Chariton rivers.

Nebraska.—Considerable work is being done to protect the bottom lands of the Missouri from the overflow of the tributaries coming from the bluffs.

New Jersey.—The State has made appropriations ($23,000 in 1907) for ditching the salt marshes for the purpose of exterminating the mosquitoes. Although the work enables marsh hay to be grown, diking against high tides is necessary for complete reclamation.

North Carolina.—Very little work has been done, but the State recently turned over to the control of its Geological Survey two swamps aggregating 55,000 acres. This was done for the purpose of studying the feasibility of draining them. A state drainage convention was held September 9 and 10, 1908, to stir up interest in drainage and to devise means for prosecuting the work.

North Dakota.—Preliminary surveys were made several years ago to protect thousands of acres from Red River, but no actual construction work has been done.

Oregon.—In connection with an irrigation project a considerable portion of the swamps in the vicinity of Klamath Lakes is being drained by the United States Reclamation Service.

South Carolina.—The only considerable work is the continuation of the work of the sanitary and drainage commission of Charleston County in reclaiming the swamps of that county. This commission was organized under the state laws.

South Dakota.—Several drainage districts have been organized to drain the lands in the Missouri bottoms.

Texas.—A number of drainage districts have been organized to reclaim land in the southeastern part of the State.

Virginia.—At present nothing is being done to reclaim the largest swamp area in the State—the Dismal Swamp. Capt. John G. Wallace, who has spent his life in that region, states that no steps will be taken by the owners until the route of the proposed Chesapeake and Albemarle canal is decided upon, as that will influence the drainage problem.

Wisconsin.—Drainage is being pushed fairly actively, with the result that thousands of acres have already been reclaimed.

Nothing is being done in the States omitted from the foregoing list. In most of them the swamp areas are small and scattered.

WORK OF THE UNITED STATES GEOLOGICAL SURVEY.

By two branches of the Geological Survey work is being done which has an important bearing on the reclamation of swamp lands; these are the topographic and the water-resources branches.

The work of the topographic branch consists in making a topographic map of the entire country, about 35 per cent of which has been completed. It includes a considerable portion of the swamp and overflow areas, and in addition to the actual swamp lands the higher land adjacent has been mapped, a work which is essential to a thorough understanding of the drainage problem. In connection with the surveys for mapping purposes, level lines are run giving accurate elevations, and thus much information necessary for making drainage plans is obtained.

In the water-resources branch the work consists chiefly in maintaining records of flow of the principal streams, and in this way data are being collected regarding the flow of streams that are either outlets for swamps or that overflow their bottom lands. While the information gathered is of importance in connection with the reclamation of lands of both types, it is especially valuable in the matter of leveeing overflowed lands, where the maximum discharge must be known if the reclamation is to be complete.

Besides the above work, data are being compiled relating to size and location of various swamp areas, in order that a map of each State, showing swamp conditions, may be prepared. Methods and cost of reclamation are also being studied, in order that the cost of future work of the same kind may be closely estimated.

SWAMP AND OVERFLOW LANDS.

By Dr. A. C. True,
Director of Office of Experiment Stations, U. S. Department of Agriculture.

The term "swamp and overflow lands," as commonly used, refers to lands which in their natural state are unfit for cultivation by reason of their swampy and overflowed condition. The term, as used by agriculturists, has reference to lands which can not be profitably cultivated without draining. The total area of swamp and overflow land in the United States was ascertained by a recent investigation made by the Department of Agriculture as 79,005,023 acres. These lands are classified as follows:

	Acres.
Permanent swamp land which is never fit for profitable cultivation or grazing	52,665,020
Lands which afford pasturage for stock, usually termed "wet grazing land"	6,826,019
Lands which in their natural condition are subject to periodical overflow by streams, but which at other times produce valuable crops, and called "periodically overflowed land"	14,747,805
Lands which may be profitably cultivated during seasons of light rainfall, but in other seasons are too wet for cultivation, and designated as "periodically swampy land"	4,766,179
Total	79,005,023

In addition to this area there are 100,000 acres of land in the arid west, once irrigated, which have been abandoned because of swampy or wet condition, and an additional 661,000 acres which are only partially productive because of their wet condition.

By the act of Congress of 1850, and subsequent acts, all federal swamp and overflowed lands were granted to the States in which they were located. With the exception of 3,200,000 acres of ceded Indian lands in the State of Minnesota and an undetermined amount in the State of Florida not yet claimed by the State, all the swamp and overflowed lands are owned by individuals, companies, or States.

The term "reclaimed land" has no exact meaning, but commonly refers to wet lands which have been wholly or partially improved by draining. Lands are frequently said to be reclaimed when relieved of water only sufficiently for pasturing purposes. By many landowners the term is applied only to lands which have been drained sufficiently to produce all kinds of cultivated crops which are adapted to the climate and soil. It is estimated that 15,889,000 acres have been reclaimed for profitable farming purposes, a large part of which lies in the Mississippi River valley.

Swamp lands lying in the prairie regions have been sufficiently drained for use as lowland pastures at a cost of $2 to $4 an acre. When the same land is drained for the production of cultivated crops the cost amounts to $15 to $20 an acre, and sometimes as high as $30 an acre.

Timbered swamp land costs 25 per cent more to drain than prairie land, and $20 an acre more to clear it of stumps and prepare it for cropping.

The 15,889,000 acres which have been converted from permanent swamp into arable land are now well-improved farms which produce a maximum yield of crops. Many of such farms are worth not less than $100 an acre, the value of the land without surface improvements being $75 an acre.

A conservative estimate of the increased value of farm lands due alone to draining is $320,000,000 over and above the cost of the operations.

Of the estimated 79,000,000 acres of swamp and overflowed land it is probable that only about 60,000,000 acres can be reclaimed and made profitable for agriculture under the present condition of labor and the demand for products. The production of lands already under cultivation is being increased. The productive value of many of the unreclaimed swamp lands, when drained, is problematical.

The cost of the construction of the larger works of drainage is decreasing, by reason of improved machines and methods of excavating large channels. The cost of such work has decreased one-half during the last fifteen years. The expense of developing the land, after the main drainage has been provided, is probably 20 per cent higher than it was fifteen years ago. A safe estimate for draining 60,000,000 acres sufficiently for good farming land is $20 an acre.

Our country could support 600,000 more families upon farms thus drained, and as many more who would be engaged in other occupations in the towns and villages which would follow the development of the land.

TENURE OF FARM LANDS.

By Prof. **Le Grand Powers**,
United States Census Bureau.

For the last half century at least there has been a decided tendency toward smaller individual farm holdings. The data upon which this statement is based were obtained largely from the reports of the United States Census Bureau. These reports for the various census years are on slightly different bases, and a statement of the differences may as well precede an exhibit of the facts to be gleaned from the reports of that office.

The first statistics of American farm holdings that can be compared with those of the present day were collected in 1850. In that year the United States census ascertained the number of farms and the total number of acres in farms, and thus obtained the data for determining the average size of farms. It did not, however, ascertain how many of these farms were cultivated by owners and how many by tenants, the number of separate individuals who owned farm lands, or the total number of farms of any specified area. The information collected by the census in 1860 and 1870 was identical in character with that secured in 1850.

In 1880 the census began to collect information relating to farm tenure, or the number of farms cultivated by owners and tenants, and tabulated the data so as to show the number of farms of each of a number of specified areas. The information collected and the tabulation employed in the census of 1880 have been made use of in each succeeding census, including that of 1900. In addition, the census of 1900 secured and tabulated certain information relating to the ownership of tenant farms. The data thus collected for six decennial years furnish a fair basis of ascertaining the trend in the greatest of American industries with respect to the average size of the holdings occupied and cultivated by a farm owner or farm tenant and the average size of holdings of the persons owning farm land. The facts disclosed by these census data are here discussed under a number of distinct heads, the first to be considered being that of the average holdings of those who occupy and cultivate farm land. The facts relating to this subject are reviewed under the title which follows:

DECREASED HOLDINGS OF FARMERS OR FARM CULTIVATORS.

For the purpose of summarizing these data the census arranged the States and Territories of continental United States into five divisions, to which it gave the names of North Atlantic, South Atlantic, North Central, South Central, and Western.

The census data showed that the past changes and present conditions with respect to holdings in the States which were fairly settled before 1850 were different from those changes which have taken place or the conditions which exist in the great majority of States settled in later years. To bring out the difference here noted, the North Central and South Central States were divided into two groups, here referred to as "old" and "new." The "old" North Central States are Ohio, Indiana, Illinois, Iowa, Missouri, and Michigan; the "new" North Central States—Wisconsin, Minnesota, Kansas, Nebraska, North Dakota, and South Dakota. The new South Central are Texas and Oklahoma. The data for the latter were given in the census reports under the title of Oklahoma and Indian Territory. All the other States of the South Central division are here referred to as the old South Central. The States and Territories included in the North Atlantic, South Atlantic, and old North Central and old South Central divisions are here referred to as the older group and all other States as the newer group. The data collected by the census showed that in the older group there has been a marked and almost unbroken tendency toward smaller holding by individual farm cultivators from 1850 to 1900. Every State within this group had a smaller average area of farm holdings in each census year than it had ten years previous; but combining the data of these individual States into groups, the old North Central had an average greater in 1890 than in 1880, due to the different combination of the data for the individual States. In the newer group there was a marked tendency from 1850 to 1870 toward smaller holdings, but since that time a tendency in the opposite direction. The average size of the farm holdings of individual cultivators was given for each of the two groups and the seven divisions of States here mentioned for each of the census years from 1850 to 1900:

TABLE 1.—*Average acreage of holdings of farm cultivators, 1850 to 1900.*

Groups and divisions.	1900.	1890.	1880.	1870.	1860.	1850.
United States	147.0	136.5	133.7	153.3	199.2	202.6
Older States	103.4	117.0	124.0	147.7	190.9	194.6
North Atlantic	97.5	95.3	97.7	104.3	108.1	112.6
South Atlantic	109.1	133.6	157.4	241.1	352.8	376.4
Old North Central	112.2	115.4	114.3	122.3	141.3	143.0
Old South Central	91.3	121.7	136.4	179.9	286.0	250.8
Newer States	297.7	205.8	179.6	195.7	286.6	488.4
New North Central	213.2	171.1	143.3	130.1	129.4	147.8
New South Central	324.4	223.7	208.4	301.0	590.9	942.5
Western	393.5	324.1	312.9	336.4	366.9	694.9

FARMS OF SPECIFIED AREA.

Mention has been made of the fact that since 1880 the census has so tabulated its data relating to farms and farm area as to disclose the number of farms of specified area. The data thus secured were given for the United States and for the two general groups mentioned in the following table:

TABLE 2.—*Number of farms of specified area, 1880 to 1900.*

Area in acres.	United States.			Older States.			Newer States.		
	1900.	1890.	1880.	1900.	1890.	1880.	1900.	1890.	1880.
Under 10	233,697	150,194	139,241	198,058	135,979	127,219	35,639	14,215	12,022
10 and under 20	406,641	265,550	254,749	352,193	237,525	227,067	54,448	28,025	27,682
20 and under 50	1,257,496	902,777	781,574	1,047,060	778,134	684,394	210,436	124,643	97,180
50 and under 100	1,366,038	1,121,485	1,032,810	1,096,239	928,477	874,573	269,799	193,008	158,237
100 and under 500	2,390,282	2,008,694	1,695,983	1,590,818	1,408,227	1,309,602	799,464	600,467	386,381
500 and under 1,000	102,526	94,395	75,972	44,599	64,674	61,197	57,927	29,721	14,775
Over 1,000	47,160	31,546	28,578	13,094	17,541	20,857	34,066	14,005	7,721

In the compilation of the tables no account was taken of a certain small number of farms reported in 1900 which contained less than 3 acres. They were omitted as being of a character not included in the earlier census reports and their inclusion would make the figures not strictly comparable for the several years.

In the older group there was a continued and unbroken increase in the number of farms containing less than 500 acres and a corresponding decrease in the number of farms of greater area. The increase in the average size of farms shown for this group in Table 1 was, therefore, caused principally by a breaking up of the larger farms of the earlier years and the substitution of smaller ones in the later. At the time of their settlement there was the same tendency in the older States to acquire large holdings that is to be witnessed in the newer States at the present time. Then, as now, men who obtained land for nothing or for a nominal consideration secured all they could without regard to the area that could profitably be utilized by them for agricultural purposes. Later the holdings thus obtained must be adjusted to the area that can most economically be cultivated by the individual farmer. In the older group this has tended for fifty years to be of smaller and smaller area. Time alone can tell whether such will be the tendency in the newer group. All available information leads, however, to the conclusion that the census of 1910 will disclose a marked tendency in the newer groups of the same character as the one shown in Table 2 for the older group.

OWNERSHIP OF AGRICULTURAL LAND.

The Twelfth Census was the first to collect data relating to the ownership of rented farm land, although the information secured was not sufficiently complete to establish definitely the total number of individuals owning farm land and thus the average size of the holdings of such owners; yet it suffices for the student of the subject to establish that number and that area within narrow limits for correctness. Well-known facts relating to agricultural lands and agricultural holdings in 1850 enable the student to secure the same data for the date mentioned within narrow limits of accuracy. The comparison of the available data throws much light upon the question: Has the title to American farm land tended in the last fifty years to pass to a fewer or larger relative number of individual owners?

In 1848 Gov. John Young, in his message to the New York legislature treating of the legislation needed to enforce the provisions of the third constitution of that State, adopted in 1846, forbidding the longer continuance of the feudal tenure of agricultural land, estimated that the manorial holdings in New York aggregated 1,800,000 acres, and that 260,000 people were residing on such holdings. These 1,800,000 acres were owned by relatively few proprietors. The number of separate farms on this area could not have been less than 30,000 and may have exceeded 40,000, provided the estimates of Governor Young concerning the population residing upon the same were correct; and the number of farm owners in the State was less than the number of farms by not less than 30,000, and it may have been less by over 40,000. The foregoing figures assume that the great number of tenant farms in New York in 1850 other than those held in feudal or manorial tenure were occupied by the children of their owners. Making the same exception for the older States previously mentioned, and combining the statement of Governor Young with the census returns of the number of individual farms, the conclusion is reached that the number of persons residing in the older States and owning farm land in 1850 was not more than 1,370,000, and it may not have been over 1,350,000; and the area owned by each averaged not less than 200, and that average may have been as great as 203.2 acres. In the newer States in 1850 the census reported only 39,244 farms, with an average area of 488.4 acres. The number of persons owning tenant-operated farms was doubtless nearly as great, if not quite the same, as that of such farms; and hence the average area of land held by an individual owner was not less than 488 acres. Taking the country as a whole, and combining the data reviewed for the two great groups, we reach the conclusion that in 1850 the number of persons owning farm land in the United States numbered not less than 1,390,000, and may have reached 1,410,000, with an average in the one case of 211.2 acres and in the other of 208.3 acres.

Of the 5,737,372 farms in continental United States in 1900, 2,024,964 were operated by tenants and 3,712,408 by their owners. It was further ascertained that 1,257,716 different persons owned 1,934,346 tenant farms whose owners were ascertained. The number of tenant farms, the names and residences of whose owners were not ascertained, was 90,618. For the farms whose owners were ascertained, there was one owner for every 1.54 farms. Allowing the same relative number of owners for the farms with ownership not reported, the tenant farms of the United States in 1900 were owned by 1,316,516 separate persons. Of these persons a limited number were operating owned farms, and thus included in the 3,712,408 persons operating farms of their own. The number of these persons was not ascertained. It probably was not less than 10 per cent and was with equal probability not more than 20 per cent of the number of persons owning leased farm land, or in other words, was not less than 130,000 and may have reached 275,000. Allowing these numbers, we find that the number of different persons owning farm land in 1900 was not less than 4,563,000 and may have equaled 4,893,000. The average holdings of the individual owners, therefore, was not less than 171.2 nor more than 176.5 acres.

The foregoing figures may be compared with the corresponding totals for the United States in 1850 when the average owned acreage of farm land was not less than 208.3 and may have equaled 211.2 acres. In spite of the enormous holdings of a few owners in the newer States, some of which holdings are over 1,000,000 acres, the general movement of agricultural land is not only to be cultivated in smaller holdings but is to be owned in smaller parcels.

The data secured do not admit of satisfactory analyses along the same lines for the several groups of States, owing to the fact that some land located in one State or group of States is owned in other States. Allowing somewhat for this fact, the data obtained lead to the conclusion that in 1900 the 4,317,243 farms of the older group of States were owned by not less than 3,550,000 and by not to exceed 3,700,000 persons. This would give the average area owned by an individual of not less than 120 nor more than 125 acres, as compared with the average in 1850 of 200 to 203.2 acres. The area of land owned by an individual capitalist has, therefore, decreased in these older States almost as much as has the area tilled by the average farmer.

CAUSES OF TENDENCY TO DECREASE FARM HOLDINGS.

The principal tendency to decrease farm holdings is social in its origin. The abolition of slavery changed the status of a great army of farm toilers; men who once were slaves, if retained on the farm, must be owners, tenants, or hired laborers. Since emancipation there has been a social movement among former slaves which has elevated a great portion of them and of their descendants, and they have become farm tenants. The small capital and lack of skill on the part of these former slaves, as well as the absence of any large amount of possible hired labor, makes these former slaves occupiers of small farms, and their rise to tenancy becomes a most potent factor toward lessening average farm holdings.

A change in the average status of farm labor in the old Northern States has the same influence. The possibility for poor men who leave the East and go West to become owners of farms carved out of the Government land has, with the passage of years, made an increasing number of adult male farm workers unwilling longer to toil for wages on the farm. If they can not secure a farm in the Northeast as a tenant, they will leave that section of the country and drift to the West. Hired labor can not be easily secured by those who have passed the age at which they wish to engage in hard farm labor. As a result, tenant labor displaced hired labor in the North as it displaced slave labor in the South, and with the decrease of hired and slave labor and an increase of tenant labor, the number of independent farms and farmers increases and thus forces a change in the size of farm holdings for the cultivation of the soil. Within narrow limits, the factors which determine the amount of land that the average farmer cultivates under his immediate management also determine the area of the tract which the average individual capitalist will acquire and continue to own.

Whatever may have been the effect upon the production of the soil of this decrease in the size of farms cultivated by the average owner, there can be no question that the decrease and the consequent enormous increase, actual and relative, in the number of farm owners is of tremendous social significance. It measures the enormous increase of independence among the farmers and a corresponding decrease in the number of farm dependents, as can be seen by an analysis of the constituent parts of American farm population which follows.

FARM TENURE AND THE STATUS OF FARM LABOR.

The census statistics of occupations for the later census years have been taken and compiled on a basis quite different from that of 1850. As a result, no comparison can be made between the status of agricultural labor in 1850 and 1900 without making use of some estimates for the earlier year. The writer estimates on the basis of the census data for 1850 and later years that the males employed in agricultural labor on American farms in 1850 could not have been less than 3,500,-000. At that time the farms numbered 1,449,073, some of which were operated by women, as has been the case in all subsequent years. Of the 1,449,073 farms, not less than 40,000 in New York alone were operated by tenants, according to the data contained in Governor Young's message in 1848, and the number may have exceeded 50,000. The total number of tenant-operated farms in the United States could not have been less than 100,000; and of 1,000 farm owners and tenants, and males over 15 years old other than owners and tenants, working on American farms, approximately 376 were farm owners, 28 farm tenants, 373 were wage-earners and children of farm parents, and 223 slaves.

In 1900 the males 15 years of age and over working for wages in continental United States numbered 8,549,739. The farms tilled in part or wholly by their owners were 3,712,408, and those tilled wholly by tenants were 2,024,964. For every 1,000 farm owners, tenants, and male workers other than owners and tenants over 15 years of age engaged on farms, there were 417 farm owners, 227 farm tenants, and 256 others, of whom substantially one-half worked for wages or for their parents.

The relative number of farm owners was greater in 1900 than in 1850; the relative number of tenants was much greater in the later than in the earlier year, and has shown a tendency to uninterrupted increase, while that of the lowest form of farm labor has shown a most marked tendency to decrease in relative importance. With slight changes in the relative condition of farm work, there has been a tendency in fifty years to substitute tenant labor for slave and hired labor, and this tendency has been a most important factor in affecting farm tenure, the average size of farm land cultivated by the individual farmer, and indirectly in increasing the relative number of persons owning farm land and in decreasing the size of land owned by the average individual landlord.

FISHERIES OF THE UNITED STATES.

By Dr. Hugh M. Smith,
Of the Bureau of Fisheries, Department of Commerce and Labor.

The following table gives the principal annual statistics regarding the fisheries of the United States:

Items.	Total.	
	Number.	Value.
Persons employed	219,534	....
Vessels fishing	4,899	$9,425,723
Tonnage	97,188	....
Outfit	....	3,443,724
Vessels transporting	2,038	4,687,891
Tonnage	92,402	....
Outfit	....	371,465
Boats	83,800	6,040,438
Seines	5,652	893,083
Gill nets	253,228	2,449,734
Trammel nets	1,811	85,690
Pound nets, trap nets, and weirs	12,912	3,602,408
Fyke nets	60,203	360,169
Stop nets	359	22,202
Beam trawls	75	2,267
Paranzella nets	32	5,800
Wheels and slides	90	109,255
Lines	....	416,494
Eel pots	29,956	27,413
Lobster pots	198,130	221,561
Dredges, tongs, rakes, and hoes	....	400,101
Crab dredges and scrapes	....	11,791
Crowfoot grapples, rakes, etc.	....	13,683
Sponge apparatus	....	6,663
Other apparatus	....	94,435
Shore and accessory property	....	35,853,934
Cash capital	....	25,648,914
Total	....	94,254,839

The following table shows the annual amounts and value of the products of the fisheries by species:

Products.	Pounds.	Value.
Alewives	52,061.580	$473,811
Barracudas	2,194,717	53,073
Black bass	1,939,571	150,471
Bluefish	16,575,661	781,802
Bonito	1,231,094	44,893
Buffalo fish	14,534,141	340,397
Butterfish	4,184,363	138,761
Catfish	12,718,003	531,529
Cod	85,193,618	2,295,068
Crappie and strawberry bass	1,397,306	61,188
Croaker	7,032,243	142,076
Cusk	9,079,866	139,964

Products.	Pounds.	Value.
Drum, fresh-water	3,512,881	87,94[illegible]
Drum, salt-water	4,063,230	109,0[illegible]
Eels	3,815,916	223,8[illegible]
Flounders	18,094,317	445,6[illegible]
German carp	18,942,763	442,2[illegible]
Haddock	77,065,441	1,258,70[illegible]
Hake	35,928,627	419,38[illegible]
Halibut	15,806,776	590,90[illegible]
Herring	87,846,283	728,2[illegible]
Herring, lake	32,177,689	816,04[illegible]
Mackerel	16,458,604	1,110,4[illegible]
Menhaden	562,427,449	1,452,0[illegible]
Mullet	[illegible]1,747,130	709,4[illegible]
Paddlefish	1,421,086	45,9[illegible]
Paddlefish caviar	11,171	7,0[illegible]
Perch, white	2,674,763	160,87[illegible]
Perch, yellow	7,080,770	182,27[illegible]
Pike perch	10,899,604	457,97[illegible]
Pike and pickerel	1,451,270	79,72[illegible]
Pollock	29,033,093	305,4[illegible]
Pompano	910,155	61,4[illegible]
Rockfish	1,896,467	63,4[illegible]
Salmon	267,601,561	12,615,74[illegible]
Scup	9,216,731	250,2[illegible]
Sea bass	4,282,313	183,21[illegible]
Shad	28,563,385	1,702,37[illegible]
Sheepshead	2,634,046	68,0[illegible]
Silver hake	5,549,935	37,9[illegible]
Smelts	3,414,662	152,4[illegible]
Snapper, red	13,763,653	418,3[illegible]
Snapper, other	401,349	11,41[illegible]
Spanish mackerel	3,673,846	171,97[illegible]
Spot	2,023,476	65,7[illegible]
Squeteague	44,783,504	1,265,5[illegible]
Striped bass	4,171,758	352,04[illegible]
Sturgeon	3,146,398	149,54[illegible]
Sturgeon caviar	114,814	83,40[illegible]
Suckers	9,538,639	196,304
Sunfish	2,088,519	52,00[illegible]
Swordfish	3,311,369	205,5[illegible]
Tautog	847,756	28,2[illegible]
Trout	20,158,954	1,081,117
Whitefish	7,728,761	350,18[illegible]
Whiting and kingfish	1,178,650	56,107
Other fish	13,651,988	313,82[illegible]
Clams, hard	9,064,852	1,385,44[illegible]
Clams, soft and other	8,438,510	574,00[illegible]
Mussels	1,580,065	8,4[illegible]
Mussel shells	51,856,430	530,0[illegible]
Oysters	217,787,610	18,449,104
Oyster and other shells	19,983,845	20,70[illegible]
Scallops	1,586,151	297,6[illegible]
Abalone	824,948	9,15[illegible]
Squid	1,370,729	27,361
Cockles, winkles, conchs, etc	93,734	13,510
Crabs	49,219,543	905,74[illegible]
King crab	2,303,000	8,90[illegible]
Lobster	11,898,136	1,364,721
Spiny lobster	1,133,729	46,6[illegible]
Crawfish	447,664	20,90[illegible]
Shrimp and prawn	17,689,539	393,6[illegible]
Shrimp shells	950,000	4,300
Sponges	346,889	364,422
Terrapin and turtle	1,4[illegible]9,314	114,494
Oil, fish	745,162	20,047
Oil, whale	4,[illegible]1,973	267,361
Oil, sea-elephant	590,625	25,000
Whalebone	176,141	722,651
Ambergris	94	16,900
Fur-seal pelts	92,364	484,649
Sea-elephant skins	5,000	600
Alligator hides	349,927	40,779
Otter skins	6,861	35,110
Seaweeds	900,320	36,287
Other products	4,545,829	129,391
Total	2,033,992,699	61,047,909

The following table summarizes the fish-cultural operations of the bureau:

Summary of distribution of fish and eggs, fiscal year 1908.

Species.	Eggs.	Fry.	Fingerlings, yearlings, and adults.	Total.
Catfish			277,601	277,601
Carp			350	350
Buffalo fish			40,500	40,500
Shad	760,000	79,316,600		80,076,600
Whitefish	139,266,000	384,480,000		523,746,000
Lake cisco	12,790,000	3,200,000		15,990,000
Chinook salmon	68,385,550	24,998,185	2,231,797	95,615,532
Silver salmon	296,000	13,420,714	57,932	13,774,646
Blueback salmon	75,000	69,883,305		69,958,305
Humpback salmon		7,185,748		7,185,748
Steelhead trout	333,725	1,123,146	59,000	1,515,871
Rainbow trout	830,000	253,650	2,713,600	3,797,250
Atlantic salmon		2,079,514	30,003	2,109,517
Landlocked salmon	190,000	441,281	151,526	782,807
Blackspotted trout	768,380	4,230,540	1,442,376	6,441,296
Loch Leven trout			55,012	55,012
Lake trout	2,734,000	25,267,078	3,182,080	31,183,158
Brook trout	1,473,400	6,307,048	3,471,292	11,251,740
Sunapee trout		191,736		191,736
Grayling	200,000	1,047,000		1,247,000
Pike			17,550	17,550
Crappie and strawberry bass			200,268	200,268
Rock bass			25,090	25,090
Warmouth bass			1,638	1,638
Small-mouth black bass		232,312	78,940	311,252
Large-mouth black bass		23,900	588,047	611,947
Bream or sunfish			202,810	202,810
Pike perch	218,725,000	193,438,000		412,163,000
Yellow perch	2,080,000	382,576,000	68,045	384,724,045
Striped bass		4,333,500		4,333,500
White perch	5,740,000	321,670,000		327,410,000
White bass			500	500
Fresh-water drum			26,000	26,000
Cod	3,000,000	235,365,000		238,365,000
Flatfish		389,642,000		389,642,000
Pollock		66,454,000		66,454,000
Tautog		794,000		794,000
Lobster		180,932,000	1,011	180,933,011
Total	457,647,055	2,398,886,257	14,922,968	2,871,456,280

In addition to the work of the United States Government, several of the States carry on independent fish-cultural operations, the results of which are summarized in the following table:

Number and species of fish planted by States conducting important fish-cultural operations.

Species.	California, 1906.	Colorado, 1905-6.	Maine, 1907.	Maryland, 1905.	Michigan, 1903.
Shad				11,667,000	
Pacific salmon	97,731,100				
Steelhead	352,000				
Landlocked salmon			575,380		
Various trouts	1,446,000	11,000,000	993,700		6,800,000
Lake trout			487,620		930,000
Grayling					200,000
Black bass					901,200
Pike perch					30,350
Yellow perch				121,591,000	
White perch				4,300,000	
Total	99,529,100	11,000,000	2,056,700	137,558,000	8,861,550

Number and species of fish planted by States conducting important fish-cultural operations—Continued.

Species.	New York, 1906.	Pennsylvania, 1906.	Oregon, 1904.	Washington, 1906.	Wisconsin, 1906.	Number planted.
Shad	400,000	3,018,000	....	....	....	15,085,[illegible]
Whitefish	38,225,000	36,468,000	....	....	53,780,000	128,473,[illegible]
Lake herring	....	39,128,000	....	....	....	39,128,[illegible]
Pacific salmon	....	....	22,922,334	57,650,000	....	178,309,[illegible]
Steelhead	....	....	143,849	4,070,450	....	4,566,[illegible]
Landlocked salmon	....	....	....	....	....	575,[illegible]
Various trouts	3,745,000	9,681,750	....	....	4,598,900	38,265,[illegible]
Lake trout	6,015,000	6,170,000	....	....	16,107,000	29,709,[illegible]
Grayling	....	....	....	....	....	206,[illegible]
Smelt	74,000,000	5,000,000	....	....	....	79,000,[illegible]
Pickerel	....	179,600,000	....	....	....	179,600,[illegible]
Muskalunge	4,983,000	176,000	....	....	800,000	5,959,[illegible]
Black bass	....	73,100	....	....	1,162,000	2,136,[illegible]
Pike perch	75,045,000	53,700,000	....	....	79,140,000	207,915,[illegible]
Yellow perch	515,000	64,395,000	....	....	....	186,501,[illegible]
White perch	....	....	....	....	....	4,300,[illegible]
Tomcod	30,700,000	....	....	....	....	30,700,[illegible]
Lobster	2,040,000	....	....	....	....	2,040,[illegible]
Total	235,668,000	397,409,850	23,066,183	61,720,450	155,587,900	1,132,457,[illegible]

It will be observed from the foregoing data that the fish-cultural operations of the United States are conducted on an enormous scale, incomparably greater than in any other country. Most of the more important food fishes and all of the prominent game fishes are included in those propagated by this bureau and the several States, but there are some valuable species which are not artificially propagated, owing either to technical difficulties, lack of facilities, or the apparent absence of the necessity.

Concerning the condition of the supply of many of the marine species of fishes it is difficult to give facts, owing to fluctuations which occur in such fisheries under the influence of natural conditions beyond man's control. There is some reason to believe that certain of the shore fisheries, as for cod, have been established and maintained largely, if not solely, by artificial propagation.

In the case of the anadromous fishes, such as the shad and the Pacific salmons, the data are definite. The shad fishery was undoubtedly maintained for many years by hatching operations solely, but recently the fishery has become so intense that most of the spawning run of fish are caught before they reach the spawning grounds and a sufficient supply of eggs for the hatcheries can not be obtained. This state of affairs has been largely induced by the indifference of the States, many of which throw the entire burden of maintaining the fishery upon this bureau while neglecting to pass laws which will permit its work to become effective. This is especially true when the shad have to pass through two or more States to reach the spawning grounds, inadequate and conflicting legislation between the interested States making abortive all efforts at efficient regulation. The salvation of the more important shad fisheries lies in bringing the States to a realization of their responsibilities, to the end of securing the passage and enforcement of efficient laws. If proper protection is afforded the spawning fish this bureau can again build up the fishery and maintain it, but at present the efforts are almost hopeless.

The same difficulty of conflicting legislation obtains in the Great Lakes. On Lake Erie, for instance, there are, including Canada, five several jurisdictions with ill-defined limits, and the consequence is that no regulations are effective. In this case, as with other northern boundary waters, the matter is now under consideration by an international commission.

The most important measures for the conservation of the fisheries lie in the production of a spirit of cooperation between the lawmaking bodies of the several States and this bureau, and it is believed that no State in which the bureau carries on fish-cultural operations should pass fishery laws without at least consulting the bureau. It would, perhaps, be well to go further and require that in case a State passes improper laws or fails to pass necessary ones, the fish-cultural operations of the Federal Government be suspended in that State until the matter is properly adjusted.

About two-fifths of the marine and fresh-water products of the United States consist of animals other than fishes, and of these the lobster is the only one which is treated by fish-cultural methods, practically all the others for various reasons being of a character to make such treatment impracticable.

Over $20,000,000 of the annual product of the fisheries is furnished by oysters, clams, mussels, and other mollusca, and sponges, which are capable of culture under private ownership. To develop these fisheries, this bureau and some of the coastwise States have long been conducting experiments and furnishing facilities, instruction, and advice, with the result that at the present time five-eighths of the entire production of oysters is derived from private beds. In those States in which oyster culture has been encouraged and developed the industry is growing, while where the natural beds are depended upon for the supply it has decreased heavily during the past 15 or 20 years. The work carried on by this bureau and the shell-fish commissions of the several States assures that this fishery, producing about $17,000,000 at first value to the fishermen and two or three times that amount ere the product reaches the consumer, is not only in no danger of failure, but is destined to future development commensurate with the growing demands of the country.

The bureau is also conducting experiments in pearl-mussel culture in the Mississippi Valley, which, it is confidently believed, will perpetuate the button industry, worth about $500,000 to the fishermen and about $6,000,000 in finished products, and which under present conditions is doomed to speedy extinction. It has also recently developed a system of sponge culture which will prevent the extinction of the sponge fishery of Florida, now producing a raw product valued at from $500,000 to $1,500,000 per year. Other works of a similar character have been completed or are now under way.

In regard to the changes in the distribution of fishes due to mining, irrigation, and drainage enterprises, and the possibility of utilizing such projects in the increase of the supply of food fishes, the bureau can give no definite information. The importance of these subjects is fully appreciated, but no investigations relating to them have been conducted. The lakes, reservoirs, and canals established in irrigation work can undoubtedly be made important local sources of food supply, but each case will have to be made the subject for special inquiry and considered on its merits. The bureau can do nothing more than theorize at this time.

The pollution of streams by sawdust, industrial wastes, and the discharge of water from mills, most of which abuses are preventable, has received some attention at the hands of this bureau, but should be the subject of further inquiry. That these pollutions do considerable injury to some of our minor fisheries is certain, and together with the results of deforestation they have ruined many streams formerly teeming with the best of our game fishes.

THE TIMBER AND STONE ACT, AND THE COMMUTATION CLAUSE OF THE HOMESTEAD ACT.

By H. H. Schwartz,
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THE TIMBER AND STONE ACT.

June 3, 1878, Congress enacted a law providing for the sale of lands chiefly valuable for timber or stone at "the minimum price of $2.50 per acre." It applied to the States of California, Oregon, Nevada, and the then Territory of Washington. The act was later extended to all of the public-land States.

I am advised that the recommendation of the Commissioner of the General Land Office that this law be enacted, and the discussions in Congress in its consideration, disclose that the act was intended to provide wood lots for settlers and preemptors upon whose lands the supply was insufficient, and timber for local use at a fair price.

In practice, however, this law has resulted in the sale of over 12,000,000 acres of valuable timber lands, of which fully 10,000,000 acres were transferred to corporate or individual timber-land investors by the entrymen. These lands brought to the people or General Government a gross sum of $30,000,000. At the date of sale they were reasonably worth $240,000,000. The profit of over $200,000,000 went not to the needy settler engaged in subduing the wilderness, but to the wealthy investors. Not over a fractional part of 1 per cent of the timber purchased from the United States under this act is held, consumed, or even cut by the men and women who made the entries.

The law requires, and each applicant makes, an oath containing among other things the following:

"That he does not apply to purchase the same on speculation, but in good faith to appropriate it to his own use and benefit; and that he has not directly or indirectly made any agreement or contract in any way or manner, with any person or persons whatever, by which the title he might acquire from the Government of the United States should inure, in whole or part, to the benefit of any person except himself."

The Supreme Court, in United States *v.* Budd (144 U. S., 154), holds that an entry and purchase made with intent to sell at an advance if the market improves, and with no intent to use the timber itself, is not a "purchase for speculation."

Up to December 1, 1908, the department assumed that the words "may be sold * * * at the minimum price of $2.50 per acre" means $2.50 per acre absolutely, as if the words "the minimum" had not been inserted.

So that since June 3, 1878, citizens and those who have declared their intention to become such have had presented to them a law under which they may lawfully enter lands worth from $2.50 up to $200 per acre, upon the following terms:

First. At $2.50 per acre.

Second. With intent to sell the same at an advance to the first buyer, and with an intent never to use the timber thereon.

With enough entrymen possessed of $500 each, or credit to borrow that amount, and a prospective buyer at a small advance, the machinery is complete for transferring title from the Government or general public to the single corporate or individual investor. The process has been automatic, and in most cases neither fraud, perjury, or false swearing is needed.

In my ten years' experience in the Government field service I have seen several heavily timbered regions suddenly go from the Government to practically single private ownership.

The process is like this:

A timber scout or estimator reports to his employers the general situation and extent of some well-timbered region. Investigation has discovered enough timber and a present or prospective market warranting more or less extensive investment. Lands already in private ownership are purchased, probably a sawmill installed, and actual operations begun. The company or investor secures estimates on the timber on each 40 acres of vacant lands. If a settler or timber and stone applicant makes final proof, he is offered a price from $100 to $500 over the cost of the land to him. At once the community—and the relatives and outside friends of the community—learns that there is a market for timber claims and that a man with $500 can practically double it in ninety days by the simple process of entering a piece of land at $2.50 and selling it at $5 or $6 per acre.

Here again the Supreme Court, in the case of United States *v.* Budd, above cited, has made plain the operation of this law. The majority of the court say one

> might rightfully go or send into that vicinity and make known generally or to individuals a willingness to buy timber land at a price in excess of that which it would cost to obtain it from the Government, and a person knowing of that offer might rightfully go to the land office and purchase a timber lot from the Government and transfer it for the stated excess without violating the act of June 3, 1878.

Since January 6, 1908, the person entering timber lands where some investor has given his notice of a willingness to buy all lands entered need not even have the $500 with which to buy, nor need he have credit upon which he may borrow that amount. The Supreme Court of the United States, in the case of United States *v.* Williamson (207 U. S., 425), decided upon the above date, holds that an entryman who has filed his sworn statement designating the particular tract he desires to purchase may, between the date of so filing and the date of actual payment—the sixty or ninety days during which he advertises his application to purchase—lawfully contract to sell or convey the land after patent issues. In other words, he may enter the lands with an intent to sell at once if he can make a profit; the corporate or individual investor may inform him that he will buy at a profit; after the entry is made, and before the applicant advances a dollar of the purchase price, entryman and prospective purchaser may contract to convey and the investor bind the bargain by depositing with entryman's attorney enough of the sale price to pay the Government for the land, and the identical money advanced on the lawful contract to sell is paid over the counter of the land office by entryman's attorney at final proof.

There is no fraud in the entryman; no risk to the investor; and a single concern may secure a wood lot of 100,000 acres in less than a year, at a profit of $1,000,000 to the corporation and at a loss of the same sum to the general public, which is the Government.

I recall a specific instance in the Susanville and Redding districts, California, where a single investor, in the course of probably three years, acquired approximately 700,000 acres of heavily timbered lands, a large amount of which was secured under the timber and stone act.

In another large operation in central Oregon trainloads of women school-teachers were shipped out from Minnesota and entered lands under the timber and stone act. A hundred citizens of Oregon made like entries. These lands were then transferred to a timber investor from Minneapolis, Minn., transfers going to him by deeds to a corporation. The articles of this incorporation were peculiar. They provided that only the president need own stock therein; its officers were composed of the president (who was the investor) and his wife and son, who were, respectively, secretary and treasurer.

During the past ten years there have been like individual operations in Montana, Idaho, Washington, and Colorado.

But if this land is worth from $10 to, say, $30 per acre for its timber, why does the entryman sell for $5? Standing alone it may be worth only $1 or $2 an acre, but as part of a large group of claims it may be worth $50 an acre. It costs money to establish logging camps, build logging roads, and erect sawmills, and find a market for the product. The owner of a single 160-acre tract could not manufacture lumber for the market. It is when the initial costs are chargeable to a large number of claims that the actual timber values appear.

There is another and controlling reason why the individual must sell, even if he has the means to hold the land as an investment. The concern owning the milling outfit or controlling the general situation may log its surrounding lands and leave him with an isolated 160 acres of timber, with no market for so small a quantity and no buyer who could thereafter log it at a profit. Also, the general system of logging is such that fire usually runs over the cut-over lands because of litter left by the loggers. That fire will destroy what few small stands of timber remain.

There are, of course, many frauds and perjuries in operations of the timber and stone lands; but they are relatively few compared to the vast number of entries made.

Of late years we have large numbers of stone entries under this act. These are usually fraudulent, with perjury involved. There is, however, no money or value loss to the Government. These stone entries are mostly in the arid and grazing regions, for lands only fit for grazing and seldom worth more than the minimum $2.50 price.

The fraud is in the oath that lands are chiefly valuable for stone. Usually the lands are more or less isolated tracts, so geographically related to the ranch of the applicant as to make it practically necessary for him to own the tract to "round out" his holdings, make it possible to fence his own land without fencing government land, secure an outlet to the open range, or some similar need.

In pursuance of a recommendation by former Commissioner Ballinger, the department, on December 1, issued new regulations requiring as to all future timber entries that the land shall be appraised for land and timber value and then sold only at such value.

THE COMMUTATION CLAUSE OF HOMESTEAD LAW.

There is no such thing as a separate and distinct law authorizing the entry of agricultural land with intent to commute. There is the general homestead law, with minor qualifications as to Indian lands. In all, however, the applicant must swear, among other things, that he takes the land in "good faith for the purpose of making a home for himself," and not for speculation or sale. And the law under which he makes his oath and original entry requires five years' residence and cultivation.

Congress, recognizing that misfortune or change of circumstances might be the lot of any settler, has provided that any homestead claimant may, after fourteen months' residence and cultivation, commute his entry—that is, purchase the land at $1.25 to $2.50 per acre.

It has been my experience and observation in ten years of field service that the commuted homestead is almost universally an entry initiated with a full intent never to make the land a home. Before the timber and stone law was extended to all public-land States the commutation clause in the homestead law was the vehicle through which timber was fraudulently acquired from the Government.

It has been my personal experience to examine solid townships in northern Wisconsin, in which practically all the even-numbered sections had been acquired under the homestead law, quite generally commutation. The timber had been cut off after patent, and yet not a single voter or inhabitant could be found in the township. The Government got $400 a quarter section for lands frequently worth from $10,000 to $20,000. More recently actual farmers have purchased these stump lands from the mill companies.

"Commutation" is the clause in the homestead law under which citizens who are not farmers or ranchers, and who have no intention of ever becoming such, enter agricultural or valuable timber lands.

While the wording of the original commutation clause required fourteen months' residence and cultivation, the department until recently held that as homestead applicants are given six months from original entry in which to establish themselves upon the land, therefore eight months' residence immediately after the expiration of this six months complied with the law as to fourteen months' residence. That construction has been given the force of actual law by the past Congress as to former entries.

Actual inspection of hundreds of commuted homesteads shows that not one in a hundred is ever occupied as a home after commutation. They become part of some large timber holding, or parcel of a cattle or sheep ranch.

As distinguished from the timber and stone entries, commuted homestead entries are quite frequently fraudulent in their inception: in that the claimant swears falsely when he or she says that the land is taken in good faith, for the purpose of making it a home, and that there is an intent to reside upon and cultivate the land.

In the bulk of cases in which homestead entries are commuted it it found that the entrymen, both at the time of entry and at the time of proof, are engaged in some business other than agricultural or grazing. They are usually merchants, professional people, schoolteachers, clerks, journeymen working at trades, cow punchers, or sheep herders. Generally these lands are sold immediately after final proof. There are few commuted homesteads upon which there is residence after final proof; and it is seldom that there is further pretense of cultivation.

Since the passage of the first commutation clause in the homestead law in 1862 there have been practically 35,000,000 acres of land acquired thereunder. The Government received probably $70,000,000 for lands worth over $350,000,000 at the time title left the United States.

The average yearly acreage commuted has been approximately 600,000. It is noted, however, that in the past few years the acreage of land annually commuted has largely increased. In 1905 there was a slight excess above 1,400,000 acres sold; in 1908 the acreage had increased to 3,124,277.

This increase coincides with the closer inspection and enforcement of the public-land law. Because of the inspection, those who are "dummies" for investors in timber, or cattle, or sheep concerns, and those who have no actual intent to make homes upon the land, are now unable to give such physical presence and cultivation to the land as will permit them to make a five-year proof. As a consequence they put in eight months time on the land, and thereupon commute. At present fourteen months actual residence is required.

I have no recommendation as to what land laws shall be enacted, but it is my opinion, after years of close personal application to this subject, that if there is one need from Congress, it is that it shall provide a reasonable fund to enable the Commissioner of the General Land Office to keep in touch with the actual conditions in the field, and make proper investigations of the manner in which public-land laws are being complied with on the one hand and abused on the other. Lands valued at hundreds of millions of dollars are annually passing from the United States to private holdings. There is an appropriation of $500,000 for this year (heretofore never more than $250,000) to cover inspection and enforcement of the law in the immense area of the public-land States.

The Government is merely the people, and whatever of the public land is fit for the home of a citizen should be held until citizens establish homes thereon. The settler should have his home free and without unnecessary restriction. But, as to lands valuable only for their timber, coal, oil, gas, or other natural resources, we may well consider whether it is not equitable that the individual who seeks for himself that which now belongs to the whole people, shall not give the people value for value in the exchange. There is no method of compelling this fair exchange other than providing the executive officers charged with the enforcement of the law with sufficient men and funds to properly and efficiently transact the people's business.

SPECIAL AGENT WORK OF THE GENERAL LAND OFFICE.

This is a statement showing approximately $110,000,000 worth of public lands believed to have been fraudulently acquired. There is reasonable prospect of recovering much of this land, if prompt action is taken.

For the fiscal year ending June 30, 1908, Congress appropriated $250,000 for the protection of public lands. A like sum had been appropriated for the year ending June 30, 1907. Public land investigations, increasing public sentiment for better protection of the national resources, and extensive discussion of these matters in publications, during the past five years, have resulted in many thousands of informations being filed in the General Land Office, charging land frauds. Many thousand cases of violation of land laws have also been brought to the attention of the Government through investigations by special agents; also, special employees of the Department of Justice have furnished the General Land Office with information in important cases.

The foregoing conditions produced great congestion in the work devolving upon the land field force. The General Land Office, local offices, and field agents receive annually thousands of complaints against claims and entries under the settlement laws. Experience shows that only about one-half of these complaints are justified. The examination of such cases has been the principal field duty—to the end that the settlement claims and entries may proceed without delay. However, the great number of extensive frauds demanding immediate action and necessarily consuming months of time in investigations and subsequent attendance in court trials leave to-day over 16,000 settlement claims suspended on complaint, out of the total 32,226 cases of all kinds pending December 1, 1908. The nature of the "necessity" for prompt action in some of the larger cases is shown in United States *v.* Juanita Coal and Coke Company, and United States *v.* Utah Fuel Company, involving lands worth $2,500,000. In these two cases the evidence of the fraudulent acquisition of these lands was finally uncovered in November last. Suits were filed December 7, 1908, and the statute of limitations would have prevented suit on December 8, 1908; likewise, in the Oregon cases against C. A. Smith et al., involving timber worth about $1,000,000, the investigations were completed, and suit was filed in May, 1908, within a few weeks of six years after patent issued. Suit can not be brought against a patent six years old.

With the $250,000 appropriated for the fiscal year ending June 30, 1907, the field force investigated and disposed of practically 6,500 cases, collected from trespassers $284,470.03, recovered 390,240 acres of land of about $2,186,400 in value, and secured the conviction in criminal cases of 138 defendants.

The present reorganization of the field force and general methods of handling the investigations in relation to public lands dates practically from the beginning of the fiscal year 1907–8. The work performed and the results accomplished in protecting public lands, recovering public lands fraudulently acquired, and prosecuting parties guilty of crimes in relation thereto from July 1, 1907, to December 1, 1908 (seventeen months), will therefore be treated as a unit. The amount appropriated for carrying on the work for the seventeen months was $500,000, viz, $250,000 for the fiscal year ending June 30, 1908, and $250,000 was expended for the first five months since that date. With this expenditure of $500,000 the following results have been accomplished:

Absolute recoveries.

10,033.07 acres of patented lands recovered (including coal lands); estimated value	$824,555.35
618,240 acres of entered unpatented lands recovered; value	3,547,100.00
Collected from timber trespassers	136,694.79
Fines collected	8,597.94

The foregoing comprise absolute recoveries to the United States of $4,516,858.08 in money value, which is $4,016,858.05 in excess of the total appropriation expended in the work. This is not, except the fines and timber trespass, money returned to the United States Treasury; but it is lands of that value restored to the public domain where the honest purchaser or settler may acquire it; and the present administration of the public-land laws is such as to prevent the recurrence of illegal acquisition. Also, the subsequent sale of the recovered coal and timber lands—now for the first time sold upon appraisal—will result in such increase in cash returns to the Treasury as will exceed the expense of recovery.

The absolute recoveries, however, constitute but a small part of the work performed and being performed. The detailed summary hereto attached shows information in the possession of the Government which may lead to the recovery of moneys and lands reasonably worth in excess of one hundred million of dollars. How effective these recoveries shall be depends upon the men and funds available for carrying on the work.

A comparison of the number of cases actually investigated in the field and reported on shows that, during the fiscal year ending June 30, 1907, 6,500 cases were examined at a total expense of $250,000, while during the seventeen months ending December 1, 1908, 28,183 cases were examined, at a total expenditure of $500,000. Taken as a whole, the work was measurably similar, and there is a consequent showing of increase in efficiency of over 100 per cent since the general reorganization of the special service.

During the past seventeen months, special agents have caused to be released from unlawful inclosure a total of 1,007,684 acres of vacant public lands. These lands were restored to settlement and the open range.

We have secured 94 convictions for violation of the public-land laws. In a large number of these cases the fines were collected, and in important cases imprisonment sentences were imposed. A tabulated statement showing details of these convictions is attached.

The field force have also examined public lands covered by rights of way, easements, and privileges granted, of which 98 were found to be either fraudulent or illegal, and adverse proceedings have been or will be instituted to free the public lands from such easements now resting thereon.

Actual investigation and examination have also been made of nine Carey Act projects, involving 199,259.18 acres. These investigations disclose projects covering 62,070.99 acres, in which the land has not been reclaimed, and in which conditions warrant action looking to the recovery of lands, either from lack of water or because lands are not desert in character. Other examinations are in progress. These do not include original examinations upon applications to select, such examinations being made by inspectors of the department.

The expectation of the General Land Office, as expressed by the commissioner to the Committee on Appropriations when considering the sundry civil bill for the year ending June 30, 1909, that an appropriation of $500,000 per year for two years would clear up the then accumulated work, will be realized.

However, the investigations of the past two years by special agents, aided by an aroused public sentiment, have produced evidence and information of wholesale and astounding frauds upon the public lands, and such cases necessarily require much time from the field force. As a result, we have of record in the special-service division of this office the 32,000 distinct cases demanding further field action, notwithstanding that during the past seventeen months there have been investigated a total of over 28,000 cases.

The magnitude of the task imposed upon the General Land Office in some of these cases will be best appreciated by example:

In a single suit to recover coal lands having a commercial value of millions of dollars it may become necessary to take the following steps:

First. Examine all of the records and correspondence in one or more of the local land offices and in the General Land Office in relation to probably 50 distinct entries of land; this examination develops the coincidence of claimants and witnesses, attorneys of record, notaries and commissioners before whom papers were executed, with a subsequent examination of probably 50 to 100 witnesses now scattered throughout the United States, and who have in one way or another been connected with the proceedings by which the Government lost title to the lands. These witnesses embrace coal experts employed by the corporations to prospect the lands, dummy entrymen, attorneys, notaries public, United States commissioners, and the various witnesses required to the different filing papers.

Second. It is necessary to examine and abstract the titles to these lands as they appear of record in the office of the recorder of deeds in the different counties.

Third. There follows the investigation of the organization and development of the corporations and holding companies who have taken over the title and who by trust deeds and mortgages endeavor to forestall recoveries by pretended purchases or incumbrances for value. This branch of the case frequently occupies months of time by men expert in real and corporate law, and frequently develops three or four companies holding titles, mortgages, trust deeds, or bonds predicated upon trust deeds, all intended simply to involve the title. In other cases subsequent transfers have proved to be bona fide.

Fourth. To the end that the value of the lands may be determined, in the event that some one of the interested corporations is able to make good its claim of innocent purchaser, and the Government is thereby driven to a judgment for damages sustained, in lieu of the recovery of the lands, it becomes necessary for men expert in coal mining and geology to make extensive field examinations.

Fifth. As these coal companies have frequently been operating from two to five years, it also becomes necessary to determine the amount of coal taken from the lands, and its value in the different situations; which may, according to the event of the suit, fix the rule of damages the Government shall recover for probably several millions of tons of coal unlawfully taken from the lands.

It will be seen that a proper presentation of the Government's case in each one of a dozen suits similar to the foregoing may well require the entire time for from three to six months of a half dozen men.

Example might also be cited of some of the more determined and persistent violators of the act to prevent unlawful occupancy of the public lands, known as the fencing law: A single case reported from Oregon involved over 85,000 acres of government land in one inclosure; in addition thereto there were a large number of fraudulent or dummy entrymen on some of the lands inclosed. If the Government expects to present such a case as this to the court or jury, with a showing which will warrant anything more than a nominal fine (which means a very nominal charge for pasturage on the public land, and the exclusion of the general community from free range), it becomes necessary, not only to show the inclosure, but to show it in detail; probably survey, chain, and subsequently plat over 100 miles of fence; investigate into the circumstances and bona fides of probably 50 to 100 entries, of one kind or another, made within the inclosure, supposedly for the benefit of the live-stock company; also interview from 50 to 100 witnesses, the dummy entrymen; the men who built the fences, to determine when they were built, and who paid for them; cow punchers, and small cattlemen, for proof that the large company controls the inclosure, and that the stock of small individuals is driven therefrom; in some cases the settlers are forcibly prevented from investigating or occupying the lands.

Again, there are conspiracy timber cases which may well take the time for from one to three months of three or four men. Along this line the land office has single cases of over 200 entries of more than 32,000 acres of land. Combinations are frequently so well organized, and so aided by defective public-land laws, as to present an almost impossible task in securing evidence or recovering lands worth hundreds of thousands of dollars. It may become necessary to assign an agent to a single conspiracy case and keep him there to the exclusion of everything else for a period of three or four months, and in certain phases of the investigation the services of other agents are required. A single timber trespass case may require a crew of men for weeks. One case investigated this year shows trespass of timber covering 7 miles of territory and timber taken of over $200,000 value. The land was unsurveyed and it became necessary to run lines and scale up this entire trespass, measuring it stump by stump. It is an old trespass, but the Government may still recover, there being no statute of limitations against a money demand.

These examples furnish indication of what the field force has done in making recoveries mentioned in the earlier part of this statement, and what now devolves upon it in successfully prosecuting the larger cases involved in the total of over 30,000 cases pending.

Following is a summary of most of the larger cases affected by charge of fraud or illegality now pending. They are here set up by State or field divisions. Details of identification and names of parties are omitted in cases under investigation for the reason that parties are entitled to such protection until investigation develops facts warranting their presentment to a proper tribunal, and on the other hand present publishing of details would generally embarrass further inquiry in a case:

Alaska.

1. Probably 500 coal claims worth at least $200 per acre on basis of 1 cent per ton	$16,000,000
2. Pending timber trespass	200,000

Arizona.

IN UNITED STATES COURT.

3. United States *v.* Grand Canyon Lime and Cement Company, to recover for timber trespass	40,000

California.

IN UNITED STATES COURT.

1. United States *v.* Hyde, Benson, et al., to recover 11,040 acres of land patented under scrip selections	110,400
2. United States *v.* English, embezzlement, indictment, amount of shortage	15,000
3 United States *v.* Dwinell et al., conspiracy, indictment, involving 1,120 acres of timber land worth	22,400
4. United States *v.* McPherrin, and 7 others, indictment, conspiracy, involving 3,840 acres of land worth	162,000

IN DEPARTMENT.

1. United States *v.* H. H. Yard et al., 200,000 acres of heavily timbered lands covered by placer location in forest reserve	5,000,000
2. United States *v.* Golden and Darby, heavily timbered lands covered by placer mining location	80,000
3. Thirty-two timber trespass cases involving	100,000

Colorado.

IN UNITED STATES COURT.

1. United States *v.* Juanita Coal and Coke Company, to recover 2,800 acres of coal lands, value $300 per acre	840,000
2. United States *v.* Utah Fuel Company, to recover 5,000 acres of coal lands valued at $300 per acre	1,500,000
3. United States *v.* New Mexico Lumber Company, to recover 8,640 acres of best timber in Colorado, value $50 per acre	432,000
4. United States *v.* Barnes et al., timber trespass	50,000

IN DEPARTMENT.

1. One group of coal entries	1,600,000
2. One group of timber land entries	860,000
3. One group of lieu land selections	3,000,000
4. Case of lands	2,000,000
5. One group of coal entries	1,200,000
6. One group of coal entries	1,280,000
7. One group of coal claims	1,000,000
8. One group of coal claims	750,000

9. One group of agricultural entries on coal lands	$4,000,000
10. One group of timber and stone entries	440,000
11. One group of timber and stone entries	200,000
12. Six timber trespass cases	335,000
13. Two cases of coal trespass, at $1 per ton	3,500,000

New Mexico.

IN UNITED STATES COURT.

1. Suits to recover 560 acres of coal lands	56,000
2. United States *v.* Coolidge et al., 640 acres of highly improved, irrigated, agricultural lands, present value over $100 per acre	64,000

IN DEPARTMENT.

1. Group of 1,120 acres of coal lands, worth $50 per acre	56,000
2. Four hundred and eighty acres in coal entries, $100 acre	48,000
3. A case of 12 coal entries for corporation, 1,920 acres, at $50 acre	96,000
4. Group of 14 desert entries, 2,240 acres, at $2.50 per acre	5,600
5. One timber trespass of 70,000,000 feet; $2 per thousand	140,000
6. One trespass case	11,050
7. Unlawful inclosure 120,000 acres	

Michigan.

IN DEPARTMENT.

1. One group of coal and timber entries of 5,400 acres, value $10 per acre	54,000
2. Fifteen timber entries	6,000
3. Two timber trespass cases	27,000

Minnesota.

IN DEPARTMENT.

1. Fourteen timber trespass cases	112,117
2. Indian reservation lands, erroneously classed swamp, timber, value	350,000

Montana.

IN UNITED STATES COURT.

1. United States *v.* B. F. Howard et al., to recover value of timbered lands entered under the mining laws	40,000
2. United States *v.* Anaconda Copper Company, timber trespass	64,934

IN DEPARTMENT.

1. United States *v.* McCune et al., trespass of 720,000 cords of wood, stumpage value	360,000
2. Eighty tracts of coal land entered under the timber and stone act, actual value $100 per acre	1,280,000
3. One lot 4,000 acres agricultural land, worth $25 per acre, acquired under the desert-land act	100,000
4. One case involving lands worth	100,000
5. Timber trespass in Missoula district, stumpage	500,000
6. One railroad and lumber timber trespass, Missoula district	500,000
7. Timber trespass case, Billings district	50,000
8. Land conspiracy, lands at $5 per acre	100,000
9. United States *v.* Libbey Placer Mining Company, timber lands held under mining locations	250,000

Nebraska.

IN DEPARTMENT.

1. Conspiracy of 4,000 acres desert land, value $5 per acre	$20,000
2. A case of 800 acres coal lands acquired by nonmineral entry	80,000
3. A conspiracy case; 18,000 acres	90,000

Nevada.

IN UNITED STATES COURT.

1. United States *v.* Central Pacific Railway Company and Southern Pacific Railway Company, 4 suits to recover mineral lands; lands have proved value in many operating mines of over	25,000,000

IN DEPARTMENT.

1. Rhyolite Township lands, group of lands held under mining locations	375,000
2. United States *v.* Central Pacific Railway Company, to recover about 300 acres of mineral lands erroneously acquired under its grant; a very conservative commercial value is	15,000,000

Oklahoma and Kansas.

IN DEPARTMENT.

1. Nine unlawful inclosures, including 302 alleged fraudulent entries of 51,720 acres, and 66,000 acres of vacant government lands; value of entered lands	517,000

Oregon.

IN UNITED STATES COURT.

1. United States *v.* Kribs et al., to recover timber lands having commercial value of	200,000
2. United States *v.* C. A. Smith, two suits to recover timber lands having commercial value of	750,000
3. Twenty-one allied suits to cancel 47 entries of heavily timbered lands	235,000

IN DEPARTMENT.

1. Case involving 75 timber entries	200,000
2. Case involving block of pine, heavy stand. 10,000 acres	250,000
3. Two unlawful inclosures of over 140,000 acres vacant land	
4. One lot of coal entries on timber land in national forest	200,000

Utah and southern Idaho.

IN UNITED STATES COURT.

1. United States *v.* Utah Fuel Company, and Pleasant Valley Coal Company et al., suits to recover title to over 40,000 acres of coal land, at $200 per acre	8,000,000
2. Court cases to recover 22,000 acres of heavily timbered pine lands worth about $30 an acre	660,000

IN DEPARTMENT.

1. About 20,000 acres coal lands held by nonmineral entries, worth about $100 per acre	2,000,000
2. One case of 3,500 acres of coal lands	70,000
3. Unlawful inclosure of 160,000 acres of vacant lands	
4. About 800 nonmineral claims to lands valuable for coal, at $50 per acre	6,000,000
5. Four hundred and eighty-eight state selections pending for examination	

Washington and northern Idaho.

IN UNITED STATES COURT.

1. United States *v.* Flynn, to recover 160 acres of improved lands	$8,000
2. United States *v.* Multnomah Mining and Development Company, to recover 256 acres of land	10,000
3. United States *v.* Barbee, to recover 640 acres coal lands	64,000
4. United States *v.* Kettenbach et al., to recover 8,481 acres of timbered lands, worth about $20 per acre	170,000
5. United States *v.* Hope Lumber Company, timber trespass	7,000
6. United States *v.* Bunker Hill Mining Company	

IN DEPARTMENT.

1. To recover 6,000 acres timber and fruit lands in the Colville Indian Reservation, held on mining claims	300,000

Wisconsin.

1. Three timber trespass cases	20,500

Wyoming.

IN UNITED STATES COURT.

1. United States *v.* Union Pacific Railway Company, to recover 5,186 acres of coal lands, at $300 per acre	1,555,840
2. United States *v.* Hyde, Benson et al., to recover 400 acres of agricultural land, at $10 per acre	4,000

IN DEPARTMENT.

1. One timber trespass, stumpage	350,000
2. One railroad timber trespass	45,000
3. Four trespass cases, value	47,432
4. One thousand seven hundred and sixty acres unlawfully acquired	15,000
5. United States *v.* Dally et al., to recover 9,500 acres of coal land, worth $150 per acre	1,425,000
6. Lander Coal case, to recover 2,500 acres of coal land, worth $150 an acre	375,000
7. Alleged attempt to acquire 2,560 acres of coal land, worth $200 per acre, by dummy system	512,000
8. Alleged attempt to acquire 2,240 acres of coal land, worth $200 per acre, by combination	448,000

Southern States.

1. Ten timber trespass cases involving	160,000
2. United States *v.* McKaskell Company	20,000
3. Florida, 5,000 acres timber land	50,000
4. Mississippi, entries	200,000
5. Agricultural entry on oil lands	20,000
Total	114,733,273

There are also set for trial and hearing 1,021 cases before local land offices, upon reports by special agents and forest officers, as follows: Alaska, 1; Oregon, 141; California, 84; Washington, 25; Montana, 227; Colorado, 77; Arizona, 41; Wyoming, 101; Nebraska, 37; Minnesota, 7; Michigan, 1; Wisconsin, 3; North Dakota, 39; South Dakota, 26; Arkansas, 47; Louisiana, 11; Idaho, 25; Utah, 6; Kansas, 13; Oklahoma, 6; New Mexico, 71; Alabama, 11; Florida, 10; and Mississippi, 8.

There are also pending in the Department of Justice and United States courts, upon reports by special agents, the following cases:

Timber trespass	161
Suits to recover lands	490
Unlawful fencing of public lands	122
Criminal cases	321
Total	1,094

These are all cases of merit to be tried. The old business accumulated on the dockets has been dismissed wherever facts warranted.

The system of handling court cases heretofore lacked proper check between the Department of the Interior and Department of Justice. There was no automatic card or record of each case to call it, and no effective order compelling whatever additional action or investigation each case demanded. To meet this situation and clear the court dockets of cases fatally defective, and ascertain what was yet required in other cases, the Secretary and Attorney-General had appointed in each court district a committee consisting of the United States attorney, a Department of Justice inspector, and a special agent of this office. This committee took up and considered each case on the court dockets or pending for suit. Cases were found of twenty years' standing; particularly in the southern jurisdictions were found many old timber-trespass cases wherein the defendants had long since disappeared. These committees recommended the dismissal of all cases wherein it was found no reasonable basis for assuming conviction or recovery could be had. As a result, there were dismissed 245 criminal cases; 71 timber-trespass civil cases; 18 cases to recover lands, and 4 fencing cases. The remaining 1,094 cases will require heavy drafts upon the time and expense of the field corps. Some of these are old cases which are now found to require additional work. Although the above cases are now in the hands of the Department of Justice, our agents must attend terms of court as witnesses; and, where additional evidence is required, the United States attorneys naturally expect agents who were familiar with a case from its inception to supply whatever further information is required.

For the Attorney-General to require his own agents to secure additional information involves the loss of time and money incident to putting an investigation into new hands not familiar with the records, facts, and witnesses. Naturally, we must remain with the case to the end.

Record of criminal cases from June 30, 1907, to June 30, 1908.

	Indictments.	Convictions.
Timber trespass	16	8
Perjury	34	8
Subornation of perjury	4	....
Conspiracy	95	6
Forgery	4	....
Securing false affidavits	8	3
Boxing trees	5	7
Unlawful inclosure	64	31
Forest fires	2	....
Misappropriations funds of United States	2	....
Total	234	63

Record of criminal cases from June 30, 1908, to December 1, 1908.

Indictments.	Found.	Convictions.	Fines.	Fines paid.	Imprisonments.
Timber trespass	21	7	$729.92	$729.92	....
Conspiracy	15	14	19,550.00	6,550.00	6
Perjury	15	....	....	....	....
Inclosure	7	14	2,003.72	1,568.02	3
Miscellaneous	21	2	....	....	1
Totals	79	37	22,283.64	8,847.94	10

The following tabulation is a summary of the unfinished work pending December 1, 1908, and given by field divisions and number of cases:

Kind of entries.	Oregon.	California-Nevada.	Washington and Northern Idaho.	Montana.	Colorado.	Arizona.	Wyoming.	Minnesota, Michigan, Wisconsin, North and South Dakota.	Missouri, Louisiana, and Arkansas.	Utah.	Oklahoma and Kansas.	New Mexico.	Florida, Alabama, and Mississippi.	Total.
Homestead	640	741	667	984	2,038	88	1,035	1,168	882	292	737	760	898	10,930
Desert	33	62	29	1,211	846	8	146	98	.....	183	.....	64	.....	2,680
Mineral	6	128	77	106	2,472	192	7	1	3	66	5	45	.....	3,108
Timber and stone	285	69	307	287	558	....	236	395	145	121	2	1	274	2,680
Coal	24	.....	54	4	705	1	72	4	.....	53	.....	9	.....	926
Selects	40	63	45	133	1	4	193	2,786	.....	488	.....	3	.....	3,756
Miscellaneous	125	174	18	142	1,181	....	155	8	.....	24	14	7	6	1,854
Timber trespass	122	81	56	116	105	64	50	330	500	44	35	57	782	2,342
Inclosure	73	66	22	548	198	60	231	116	6	24	112	171	.....	1,627
Off. Con. Invest.	9	.....	6	.....	3	4	.....	1	1	5	7	3	.....	44
Right of way, etc	.....	.....	.....	.....	349	20	.....	880	.....	23	84	78	.....	1,434
All other cases	22	14	32	54	10	55	.....	99	56	156	2	.....	.....	500
Criminal	83	11	12	20	150	....	30	8	.....	3	14	14	.....	345
Total	1,462	1,409	1,325	3,606	8,621	496	2,155	5,894	1,593	1,482	1,012	1,205	1,960	32,226

The question of values above mentioned is matter of opinion. Much of the coal is the very best in America; I have valued it at $150, $200, and $300 per acre. Should the Congress conclude to separate the coal from title to the surface in disposing of lands, and permit coal mining on a royalty basis of only 10 cents per ton, these lands would produce $1,000 per acre for 10-foot veins, this on a basis that 10 out of 18 tons are actually mined. Many of these lands in the States run from 15 to 25 feet in high-grade, workable coal; in exceptional cases, fields carry coal measuring 30 and 40 feet in thickness; in Alaska, there are pending coal entries upon coal measures as high as 60 feet thick clear coal in one vein.

The question of timber values varies according to market and locality. In the Smith cases, there are lands with 3,000,000 to 10,000,000 feet to the quarter, worth on the stump $2 and $6 per thousand feet, or over $200 an acre. East of the Cascades the timber runs much lighter, and the good timber land fraudulently acquired several years ago has from 1,000,000 to 3,000,000 feet a quarter section, generally, and is worth about $4 per thousand, or, about $50 per acre. None of these lands are culls. Later entries are generally of less value.

As to the value of mineral lands in Nevada, the estimate of $15,000,000 and $25,000,000 of demonstrated values is based on careful field examination by competent mining agents. The New York Engineering and Mining Journal has estimated these lands at $100,000,000. This refers to the particular lands already examined.

This is a summary of the work performed, and the task ahead of the special agents, given in such detail as the state of work will permit, and intended to show the value of the services being performed by special agents of the General Land Office.

This letter lays considerable emphasis upon the money value of the public domain and its natural resources. Important as is this feature of our work, it is second to that of preserving for home builders the lands fit for homes and aiding to the fullest extent every settler in his effort to establish himself upon the public domain. The positive instruction of Secretary Garfield to his field force is that, although agents are to use every endeavor to prevent land frauds and crimes, they must always keep in mind that their principal task is to speedily reach and investigate the complaints involving settlement rights, to the end that the honest settler be not harassed or delayed. To that end, as before stated, investigation has clear-listed over 13,000 cases since July, 1907. That work of itself has justified the wisdom of Congress in increasing the appropriation under this head. Experience shows that, with hardly an exception, agents have followed instructions and have given the settler a favorable report wherever good faith was shown and a real intent to make a home could be drawn from all the circumstances of the case. On the other hand, they have uniformly reported the facts as they found them, or understood them, without fear or favor, conscious of the sufficient support of their superior officers. Some of the agents new to the work may have made errors of judgment; and in any case where complaint is made that the agent's findings are not warranted or that his actions are not proper, independent investigation is made, or a hearing is had, to the end that no injustice be done either to the entryman or the agent.

In addition to the regular work of advancing the settlement of the public domain, it will be seen from the foregoing summary that, through the arms of the field force, officers and employees, it is necessary to recover over $100,000,000 worth of the people's property, alleged to have been illegally or fraudulently acquired by private individuals and corporations. The last Congress raised the fund for this work from $250,000 to $500,000. Some of the larger cases cover lands patented years ago, and the knowledge or information of fraud is but recent. It is really a race with the statute of limitations in many large matters. A most cursory knowledge of the necessity of immediate action, action before the statute of limitations intervenes, and witnesses die, or memory clouds, show the inadequacy of $500,000 per annum to recover a hundred million in jeopardy. There is need for $1,000,000 for this work. It will be returned tenfold in recoveries of national resources now held unlawfully by private parties.

NOTE.—March 3, 1909, Congress appropriated the $1,000,000 asked for this work.

RIGHTS ANALOGOUS TO SCRIP.

By S. W. WILLIAMS,
General Land Office.

Scrip and the rights analogous thereto mean the right to locate or exchange lands, the basis for such right usually consisting of other lands to which the party claiming the scrip had some right, but for some reason could not acquire title; or else of land in private ownership, which, under certain conditions, may be exchanged with the Government for other lands.

Scrip rights, however, are not always based upon the loss or exchange of other lands, for Congress has granted scrip in the form of bounty land warrants for military service. Akin to this is the soldier's additional homestead right granted by the act of June 8, 1872 (17 Stats., 333).

The term scrip, of course, means a writing of some sort, but in land practice it has grown to represent the right to locate land even where no actual certificate, warrant, or other paper is issued. Thus the right of a soldier or his assignee to make an additional homestead entry, or the right of the owner of lands in a national forest, under the act of June 4, 1897 (now repealed), to exchange such lands for others, is termed scrip, though in neither case was it usual for the Government to issue any certificate or other writing as evidence of such right.

In other instances, as in the case of surveyor-general scrip under the act of June 2, 1858, supreme court scrip under the act of June 22, 1860, and other cases, it was made the duty of some designated officer of the Land Department to issue the written certificate or warrant.

It may be said that it is the office of scrip to enable its owner to acquire title to public lands without the necessity of residing, settling, or making any improvements whatever upon the lands to be acquired; and the quantity of land which may be located is determined only by the quantity of scrip which can be secured. The practice of selling the public lands indiscriminately to anyone possessing the necessary money to pay the purchase price (which I may say in passing has always been grossly inadequate) was abandoned years ago, and now only those possessing certain qualifications, and generally upon conditions more or less arduous, may secure lands by the payment of money, and even then only in limited quantities.

This, together with the fact that scrip is usually transferable by a simple assignment, renders it very valuable, and an object of eager search. Its importance as a factor in the acquisition of public lands becomes at once apparent, and the effect upon the morals of the land-seeking public is equally noticeable.

Lawyers who might otherwise have become an honor to their profession have degenerated into speculative scrip dealers. Men of good standing in their communities have not hesitated to commit perjury in behalf of their friends who supposed, from a mere similarity of names, that they were entitled to certain rights. Notaries public have disgraced their seals and prostituted their office by the making of false jurats. And even the probate courts have been converted into mere machines for the production of ready-made administrators, regardless of the domicile of the parties or the locus or ownership of the rights involved.

It naturally follows that claims established in this manner will not bear investigation. In the case of mere rights, without any accompanying certificate, there is no occasion for investigation until an application is made to locate the right upon a specific tract of land. The location may fail—it frequently does—but in the meantime the locator, who may have purchased the right in good faith, has at least some color of title, and if he should remove the timber from the land, he would be liable only as an innocent trespasser and could be made to pay only the stumpage value of the timber. The land would be denuded of its timber and yet not be cleared land suitable for cultivation, and, considering the cost of the investigation, the result would be a net loss to the Government.

So many affidavits have proved false, so many forgeries have been made manifest, and so many invalid judgments rendered to "quiet title," that the Government must exercise every care possible for the protection of its interests.

Moreover, in addition to protecting itself, it is the duty of the Government to protect, as far as possible, the owners of the rights, because in many instances the identity of the real beneficiary is the only question involved.

While the difficulties encountered upon the location of rights not represented by scrip or warrants are not usually attendant upon the location of certificates which have been previously issued, it does not follow that the law is more easily administered when the right to locate is represented by a written certificate. Indeed, there is little difference whether the right is represented by a certificate or not. In the case of mere rights the difficulty is not encountered until the location is attempted, while in the case of certificates the difficulty is encountered before the warrant or scrip is issued.

In the case of surveyor-general scrip, under the act of June 2, 1858, where, as the name indicates, the right is represented by a certificate issued by the surveyor-general, most of the land claims which formed the basis of the scrip were confirmed by laws enacted prior to 1825, and many as early as 1807, while the act which granted scrip for such of these claims as could not be satisfied in place was not passed until 1858. Consequently, most of the original claimants were dead before the scrip act was passed. Their heirs or assigns had little or no knowledge of the conditions, and made no effort to obtain the benefits of the act. Notwithstanding this, hundreds of thousands of acres of the scrip were issued and delivered to persons who secured their standing as legal representatives of the confirmees through so-called probate proceedings. Of the half million and more acres of scrip so issued, it may be safely said that not one-tenth of it reached the beneficiaries intended by the law. Men of straw were appointed administrators, who either sold the claim for a nominal sum, sufficient only to defray the expenses of the probate proceedings, or who secured the scrip and sold it for its market value, converting the proceeds to their own use, no account whatever being rendered to the court, and none ever being demanded. Men of fine abilities devoted their energies to the acquisition of this scrip. The rulings of the Land Department were evaded by one means or another, and the special service of the General Land Office being then in its infancy, or not yet even in existence, the illegal traffic continued. As illustrative of the conditions and the attitude of the scrip men, I may refer to a letter written many years ago, which accidentally fell into my hands some years afterwards. In that letter the writer (a scrip dealer) informed his partner that "eternal vigilance is the price of scrip."

It was not until quite recently, when the special service of the Land Department became thoroughly effective, that an end was put to this practice. It is now more or less an open question whether the Government is liable to the real beneficiaries for the value of this scrip.

Under the forest lieu act of 1897, the right to exchange depended solely upon the ownership of land in a forest reserve. Consequently, no stone was left unturned to obtain advance information as to the creation of these reserves, in order that lands to be included therein might be acquired before the reservation became effective. Officials were bribed to furnish this information, after which every possible effort was made to acquire a title that could be exchanged, and to this end frauds were committed upon the States to induce the selection and sale of such lands.

The administration of laws which entailed such close scrutiny in the office, and such thorough investigation in the field, is necessarily expensive. It becomes necessary for the clerks employed to acquire an intimate knowledge of the laws of all the public-land States affecting in any manner the title to real estate, and the means resorted to by some of the scrip men render it necessary for the inspectors to master almost every phase of criminal law. Considering the value of the land surrendered, it would have been much less expensive if the Government had purchased the base lands for cash.

It is but proper to state that the difficulties encountered in connection with the issue and location of scrip of the classes indicated above are not usually attendant upon the indemnity selections made by railroads and the various States, owing to the fact that the Government deals directly with the railroad or the State, as the case may be, and the quantity of indemnity may be readily determined simply by a proper method of bookkeeping. Therefore, in such cases, the only question involved is the character of the lands to be located. This, of course, at times, necessitates investigations in the field to determine the character of such lands.

The quantity of indemnity to which the State is entitled under its school grant can, in no cases, be determined until all of the land in the State has been surveyed, because, until the survey is executed, it is impossible to ascertain whether or not the right of the State to the particular sections granted has been defeated. This right, of course, is affected from time to time by the creation of national forests and other reservations, and also by the settlement, by qualified persons, of unsurveyed lands. It may be said, in this connection, that, during the past fifteen years, some 6,000,000 acres of indemnity were certified to the various States, of which amount, 1,000,000 was certified during the past year.

I shall state, for the information of the commission, that the scrip rights acquired during the operation of the act of June 4, 1897, approximate 3,000,000 acres; of this quantity it is estimated that the outstanding rights, which were protected by the repeal of the act of 1897, will approximate 25,000 acres. Claims based upon deeds of reconveyance to the United States, where no selections were made prior to, and which were not protected by, the repeal by the act of 1905, are supposed to approximate 40,000 acres.

There are outstanding comparatively few surveyor-general and Supreme Court certificates, but possibly more than 2,000,000 acres are involved in the outstanding military bounty land warrants. These certificates and warrants, however, can hardly be classed as scrip at this time, because, under recent rulings of the Land Department, they may be used only in lieu of cash in the payment for lands entered under the various general laws, at $1.25 per acre; that is to say, these certificates and warrants may not be located as scrip usually is located.

Of the several kinds of personal scrip which issued under special acts of Congress there are only a few rights outstanding, some of which, however, are very valuable, owing to the fact that little limitation is imposed upon their location. Valentine and Porterfield scrip are included in this class.

Soldiers' additional homestead rights constitute, perhaps, the most important class of scrip which is outstanding. Its importance is due to the fact that it is assignable and may be located by the assignee upon any lands subject to homestead entry, no settlement, residence, or actual improvement being required. Speaking generally, the right exists where the qualified soldier made a homestead entry prior to June 22, 1874, for less than 160 acres, the amount of the additional right being the difference between the quantity originally entered by the soldier and 160 acres. The total quantity of outstanding rights, therefore, can be determined only by first ascertaining the number of entries and the quantities of land embraced therein, which were made by such soldiers prior to 1874, and, owing to the fact that many entries were made before the military service was rendered, the entry papers themselves contain no evidence whatever connecting the entryman with the subsequent soldier. This fact constitutes one of the important features of the right, and also renders the law exceedingly difficult of administration.

In the limited time allotted it is impossible to consider every phase of this subject; but one point remains which should not be passed unnoticed. The parties intended to be benefited by the scrip laws seldom if ever realize the full value of the rights granted. To use a trite figure, the men who owned the claim constituting the basis for the right, assisted by the Government, sow the seed, but the middlemen reap the harvest.

Many owners of scrip have no sense of its value, and I have heard men boast of having bought a soldier's additional right at less than one-tenth of its value. I have even heard of the purchase of a 160-acre bounty-land warrant for the sum of 50 cents. True, some of the rights are expressly made nonassignable, but even in those cases the law is evaded by the appointment of attorneys in fact, with power to locate the right and sell the land.

It will thus be seen that where scrip rights are involved, if the Government would protect its rights and those of the individuals intended to be benefited, it too must exercise eternal vigilance.

LAND CLASSIFICATION—SHOULD SURFACE BE SEPARATED?

By Fred Dennett,
Commissioner of General Land Office.

When the position of geographer of the United States, under the Department of the Treasury, was established by the act of May 20, 1785, the officer who was appointed was confronted with the proposition of, first, arranging the lands in blocks and, secondly, of securing a purchaser for them when so arranged and made capable of description. The acres were so numerous, and money needed so seriously for the debts of the United States, that it was not so much a matter of particularity as to what was sold as to finding some one who would make a bid for what was offered. There were some 1,422,000,000 acres on the market, and when an association of individuals offered $1,000,000 for as many acres in what is now the State of Ohio, they were welcomed and the deed willingly handed them.

Even in the early times, however, it was understood that there should be some knowledge obtained as to what the United States had in its public domain, and by the act of May 18, 1796, provision was made that "every surveyor shall note in his field book the true situation of all minerals, salt licks, salt springs, and mill seats which shall come to his knowledge, all water courses over which the lines he runs shall pass, and also the quality of the land." Under the law at that time the returns were filed with the surveyor-general, but by later enactment the descriptive notes, as they are called, were to be filed in the office of the register and receiver. By various subsequent enactments geological surveys of the public domain were authorized, and such surveys were made of the States of Michigan, Wisconsin, Iowa, and Nebraska and other Western Territories, but section 2406, Revised Statutes, provided that there should be no further geological surveys unless thereafter authorized by law. By the act of March 3, 1879, the office of Director of the Geological Survey of the Interior Department was established. The act provided that this officer should have direction of the geological survey and the classification of the public lands, the examination of the geological structure, mineral resources, and products of the national domain. It was held, however, by the first director that this did not give the Director of the Geological Survey the duty of classifying the public lands, to the extinction of the direction given to surveyors and their returns. In this judgment he probably was confirmed by the fact that only $100,000 was authorized for the expenses of the survey.

The records of the General Land Office show that at one time where lands were returned by the surveyor-general as mineral the same were withdrawn from all forms of disposal except under the mineral laws. This sort of withdrawal met with strenuous opposition by those desirous of securing title to lands which they alleged to be non-mineral in character, but so withdrawn, and the withdrawals were revoked by Secretary Schurz in 1880 and the practice of making suspensions, based upon the reports of deputy surveyors, discontinued.

There is no doubt but that the classification so made was inaccurate. The deputy surveyor is not a mineralogist or geologist and runs lines which are a mile apart, works for the completion of his contract and not for the exploiting of the character of the country. Local influences would be very strong and might exercise a power over him which would be to the detriment of the general service. The rough classifications were, of course, of use, but the tendency at first was to give them greater recognition than they deserved. In fact, the rough return of the deputy surveyor was contended up to within the last eighteen months as being binding on the department in a lieu selection for lands classed as agricultural, when it was a known fact that coal existed thereon, the deposits being discovered at a time subsequent to classification. It is, however, held by the department that these returns can be overcome by evidence; and to hold otherwise would be fatal.

It is a curious circumstance that the method of doing that which was recognized as a necessity when the lands were so numerous has not been improved or kept abreast of the times and pursued with greater particularity when the lands have become comparatively scarce and the necessity for classification therefore the greater.

The General Land Office issues each year a list of the "Unappropriated Public Domain of the United States," which is based upon the returns of the descriptive notes of surveyors very often made years before the publication of this document. The lands left are the "culls" and the classification, which was made of lands before they were picked over, does not fit. In some instances climatic conditions seem to have changed and at least the basic principles upon which the lands were classified are not now as they were. Methods of dry farming have made a change in the classification of that which we would have called arid lands at one time. The "brief description and character," so called, in this list, is inaccurate and misleading and there is not an intelligent understanding of that which the United States has left to offer. It was generally supposed eighteen months ago that there were but few areas left suitable for home building. During the past fiscal year, however, there have been 88,000 entries made under the homestead law and 23,000 commutation proofs accepted, a goodly percentage of which must have been perfected since that time, thus showing that the information at hand was not as perfect as a country as modern as the United States should have.

There come to the Land Office from various parts of this country and from abroad many requests for information as to our domain and the character of the land which is left. There is returned the list referred to above with a feeling that it furnishes very little that can authentically be relied upon, and the question naturally arises as to whether or not the General Land Office should not have authentic facts which would guide a would-be settler in his search for a home.

The benefits of a thorough classification would be vast even though that classification might not be conclusive for or against the government. It would give to Congress intelligent information of how to obtain the best results from the disposal of the remaining public lands of the United States; it would furnish the executive officers and their agents with a guide in attempting to follow the mandates of the legislative body; it would at least serve as a caveat to thwart those who seek to obtain unlawfully that which there are many desirous of obtaining with a full compliance with the statutes; it would be a warning that difficulties would be encountered in the acquisition of lands if sought under a law which did not embrace the lands, as classified; it would assist in the determination as to what should pass under applications under the timber and stone act. Complaints have been received from various mining districts to the effect that timber and stone applicants seek to gain possession of lands which are really mineral in character. It has been the policy of the General Land Office to watch these as carefully as possible, but the only methods of detecting the application at present are, one, by a contest instituted by an individual, and, two, after protest made, by an examination by an agent, and for the latter work there are not agents enough, but it is an undisputed fact that there are many people who would be willing to gamble $400 for 160 acres of land in the vicinity of a mineralized territory on the off-chance that at some time minerals might be found therein.

We have yet to know what the effect of the instructions recently issued concerning the purchase of timber and stone lands will be upon this situation.

Would it not be of great value to Congress, could it have submitted classified list of its lands, upon which water can be brought in some future time, to make more homes to the quarter section, so that it could consider the advisability of legislation to preserve the lands for such purpose? One of many similar instances suggests itself wherein the claimant openly asserted that he had not grown any crop upon the land he claimed as a home, and that none could ever be grown without irrigation, but he wanted the land because some day the Government would, he thought, irrigate it. When such time comes, as it will come, the object of the act of 1902 will be, to that extent, defeated. There will be but one home where Congress intended more should be built. Had the area of coal lands been ascertained, the executive officers would not be offering a record of 474,834.54 acres patented under the coal land laws, and many times that number of coal lands in private possession, obtained from the public domain. Had the timbered domain been accurately ascertained, with the character of the lands, the abuse of the commutation clause of the homestead laws, as shown in these regions, might have been stopped by Congress preventing the application of this clause to such of the public domain as presented a value in trees and not a present value in land. Laws might possibly have been enacted to fit classified areas and the lands therein, and not one law to attempt to fit all the domain alike. It has been experienced by the agents in the field that sometimes it is a severe strain on a law to make it fit all conditions, which were not appreciated or known at the time the law was passed, being enacted to cover a status known at the time and having to meet new conditions to which it was not suited, as the latter have arisen.

Out of the original 1,421,777,280 acres of the public domain, we have disposed of 1,034,903,493, leaving some 386,873,787 acres to satisfy hungry land seekers who clamor for homes. These totals exclude the estimated 368,103,680 acres in Alaska. The lands so left are naturally the poorest. Fewer acres to give away, and a greater demand for them.

In October of this year there were 4,000 160-acre farms thrown open for home seekers in the Rosebud Reservation in South Dakota. They were not free homes. There was an indebtedness to the Indians of $6 on every acre. For those 4,000 homes there were 114,769 applicants, nearly 30 people who wanted to everyone who will obtain a chance to build a home.

A great deal of the prosperity of the United States and happiness of its citizens has been due to the fact that there has been room for expansion and a place for every man. There is but one conclusion to draw from this object lesson, and that is that the few lands which are left must be put to their greatest possible use. The surface should afford a home, though tunnels honeycomb the earth beneath.

There are vast areas of land on the Pacific Coast which carry great values in their trees. Much of these areas have been sold for their tree values alone, but the soil has been purchased with the firs and spruce. Some day the sawmills will reach them and the lands will become what are called "logged-off lands." When the purchaser acquired them there was no consideration given to the value, either present or prospective, of the soil. The lands were cruised and the moneys paid for the board measure of lumber. The lands passed with the deed. There is no one living on the lands so sold. But every once and again in the woods the traveler unexpectedly sees meadow land, a farm house, and growing crops. The farmer there will have small chance of securing neighbors, even after the trees have disappeared, for the logged-off lands will be held at a price and there will not be a free home offering an opportunity for some one who would build up values on the land to take the place of the trees it has lost. Of course, ultimately the land will be used, but not as soon as it would have been if the land were open to settlement after the trees had been cut off, and a free home could have been acquired by one who has not the price to purchase the lands, but who has the brawn and willingness to force a living from the lands if he could have secured them from the public domain.

Of course there are men who like solitude. Men there are who rejoice in the fact that the "last homesteader" is moving out, for then there will be no neighbors. But it need not be argued that the greatest good is not attained where there do not live men enough to build the trails, to make the roads, and continue the work of wresting from nature the greatest returns she is willing to give.

The evils of the present practice of giving to an applicant that which he does not ostensibly seek are shown more evidently in the workings of the coal land laws, where surface rights go with the application for the coal. The question of the operation of the present law will be discussed at a later moment, and its inadequacies presented. The homesteader seeks for the farm land only. He swears that he knows of no mineral deposits within the boundaries of his farm. One instance, a sample of many, where a claimant has lived upon his farm for twenty-three years. He has slept upon his rights, in so far as filing is concerned—but that could be cured—only to find at the time of wishing to perfect proof, that below the surface there is a deposit of coal which will prevent the issuance of his patent, under the law, as it now stands. He did not and does not want the coal. He wants his home. But the law says that he must take even to the center of the earth, and can not acquire that, if workable coal be found beneath his tillable land. We are at an impasse and yet the same land could practically be utilized for the two purposes—the mine and the home.

Alaska, with its 368,021,509 remaining acres of public lands, has not been prominently brought forward in this paper. The difficulties which will present themselves in the intelligent treatment of the lands of Alaska are before us. The experience of the past should guide. We have already learned that Alaska is not a country of barren hills and waste valleys, but that there are there fruitful vales and pasture grounds. The situation in that district must be met at the outset.

These thoughts are presented for the consideration of the committee; not intended so much to be argumentative as to offer matters which are, it is hoped, worthy of attention.

PRECIOUS MINERALS ON LANDS OF THE UNITED STATES.

By **Edward C. Finney**,
General Land Office.

The history of the mining of precious metals in the United States, in so far as related to existing laws, may be said to have begun with the discovery of gold in California in 1849 and the influx of treasure seekers to remote localities where, because of the nonexistence of federal and state laws, the miners were of necessity compelled to devise and adopt rules governing the location and possession of mining claims. The rules adopted by the early miners, as stated by Justice Field—

> All recognized discovery, followed by appropriation as the foundation of the possessor's title * * * and they were so framed as to secure to all comers, within practical limits, absolute equality of right and privilege in working the mines.

The mining laws of the United States, which have been in force with slight modifications since 1866 and 1872, were drafted by men who not only represented the mining States in Congress but who had actual experience in mining operations. To a considerable extent these laws recognized and adopted the customs and local regulations previously adopted by miners on the ground, especially with reference to placer-mining claims. The law with reference to lode claims was probably, as suggested by Mr. Lindley in his work on mines, based upon the customs in vogue among the lead miners of Derbyshire, requiring location to be made upon a discovery upon the top or apex of the vein and permitting the locator to follow the vein on its dip, whether within or without the surface area of his location, to the intersection of the vein with vertical planes drawn downward through the parallel end lines of the location. With vein or lode claims the principal thing sought and to which the laws have been specifically directed is the vein itself, the right to acquire sufficient surface for the convenient working and development of the vein being accorded by the law. Lodes or veins were not placed by nature in straight lines or at regular intervals, and any change in existing laws should be framed to meet actual conditions and not theoretical ones.

Under existing laws of the United States, one who has discovered the apex of a vein or lode may locate a claim 1,500 feet in length along the presumed course of such vein with surface ground not exceeding 300 feet in width on each side of the line of the lode. The discoverer of a placer deposit (and the term placer has been construed by the

Interior Department and by the courts to include not only such precious minerals as placer gold but deposits like sapphires, sheet asphaltum, building stone, oil, and gas) is authorized by the law to locate 20 acres of ground surrounding his discovery, the location conforming as nearly as practicable with the United States system of public-land surveys. From two to eight individuals may, however, combine in making a location which shall not exceed in the aggregate an area of more than 20 acres for each locator, thus permitting eight locators to locate and obtain patent for 160 acres of placer ground upon one discovery and the expenditure of $500 in development and improvement for the entire claim. The law, however, does not limit the number of separate lode or placer locations which may be made by individuals or associations.

These laws were designed to and have had the effect of promoting the development of the mineral resources of the United States. The history of mining operations in newer fields being usually that placer deposits are discovered and worked first because this class of deposits can be mined more cheaply and readily by the individual miner than can minerals found in rock in place; thus in Colorado, California, and latterly in Alaska, the placer deposits were discovered and developed first, and very properly the existing laws have been exceedingly liberal in the matter of the rights of miners with respect thereto. Later, as the regions become more thickly populated and capital seeks investment in the field, the lode deposits are developed. The vast amounts of gold taken from mines of California and Alaska, the production in the last-named district having increased from about $1,000,000 in 1880 to over $19,000,000 in 1907, have largely come from placer deposits on the public domain or from lands acquired under the placer-mining laws. As an instance of the enormous wealth found in veins or lodes, may be cited the Independence mine in the Cripple Creek district in Colorado, reported to have been sold a few years ago to an English syndicate for $15,000,000, the Camp Bird mine in the Creede mining district in Colorado, and the silver mines of the Coeur d'Alenes in Idaho. Among the profitable mines of low-grade ore may be mentioned the Treadwell mine in Alaska and the Homestake mine in the Black Hills of South Dakota.

Improved methods of mining and in the reduction of the ores have already increased and will continue in the future to increase enormously the output of mineral wealth from low-grade ores. In the mineral regions prospectors are constantly searching for new deposits, and as a result discoveries are frequently made in localities where the existence of mineral was undreamed of. In fact, for many years stock men, prospectors, and the like passed over the Cripple Creek district without suspicion of the vast mineral wealth beneath their feet, but each new discovery widens the field and promotes search for the precious substances. After the discoveries of gold in the Tonopah and Goldfield districts in Nevada, the country far and near, even far north of Reno, looked as though colonies of gigantic gophers had been delving in the hillsides. Up to June 30, 1908, 1,269,614 acres have been patented under the mining laws.

However, during recent years, owing to the increasing value of timber and of water and water powers, there has been a temptation, to which many of the unscrupulous have succumbed, to seek to acquire title to nonmineral lands containing a growth of valuable timber, or to control the course of a stream or a waterfall by means of alleged mineral discoveries and locations, especially under the placer-mining law. This law, as heretofore indicated, is exceedingly liberal, the lands being disposed of at $2.50 per acre. It is an expeditious and easy way of obtaining title to the land. In one instance attempt was made to acquire title under the placer-mining laws to a tract of land 5 miles long and about 50 feet in width lying upon either side of a stream of water, the obvious purpose being to control the water, not to secure minerals. In a case that I investigated in California, one individual and his associates had more than 250,000 acres of lands within and about a national forest, covered with alleged placer-mining locations, each location being made by eight persons and notice of the location recorded upon the county records. Thereafter most of the claims were conveyed to the instigator of the scheme or to a corporation in which he was interested.

I found that these locations were, to say the least, impartially made, as they covered streams, valleys, mountain sides, and mountain tops. Nearly all of the claims were covered with a valuable growth of standing timber. In many instances I could find no evidence of any work whatever having been performed upon the locations; in other cases, the improvements consisted of log cabins erected from timber cut upon the lands. Most of the locations failed upon careful examination to disclose any placer mineral; and in not one instance were mining operations being carried on. One of these claims located along the course of a stream failed to disclose a single color of placer gold, but was found to be exceedingly valuable, because of the fall of the stream and the amount of water therein, for a power-plant site. When this claim was attacked, the owner failed to put in an appearance, and the claim was canceled on default. This case indicates the extent to which fraudulent locations may be made under existing laws. Many other instances have come to my attention where attempts have been made to acquire title to this class of lands under the placer-mining laws, and the location of mining claims has often been resorted to as a means of obtaining and holding possession of ground for townsite, business, or other purposes. It must be borne in mind that under existing laws one who has made a valid discovery and location of a mining claim is entitled to the exclusive enjoyment and possession of the land and is not required to apply for a patent or pay the United States for the land within any specified period. Thus fraudulent locations have the effect of depriving both the United States and its citizens of the use and possession of the ground covered thereby, and such claims are only set aside after long and expensive proceedings before the department or in the courts. In other cases, where the lands do contain placer deposits, the applicants, not being required by existing law to pay for the lands and make entry within any specific time, work out the deposits and abandon the lands, leaving to the United States the worthless residue. Another defect is that under existing laws notices of location are not required to be recorded in the local land offices nor in the General Land Office. They are recorded, if at all, either with the local mining district or county recorder, and the officers of the United States charged with supervision over the public lands have no positive knowledge as to the number or extent of such existing locations. With reference to the annual assessment work required by section 2324, Revised Statutes, to be performed upon mining claims, there is no penalty prescribed save the liability to relocation by others, nor is proof of the performance of this work required by law to be filed in the Land Department. The result is that the department, having no jurisdiction over the matter of annual assessment work, is unable to secure the enforcement of the evident purpose of the law that not less than $100 must be annually expended in development of each mineral location or to declare invalid locations based upon actual discoveries of valuable minerals, but upon which this assessment work is not performed.

To conclude, it is suggested that because of change in conditions, both with respect to the minerals themselves and the other products or appurtenances of the soil, the fact that there is no law requiring entry to be made within a definite period, that the maximum area of placer claims is too large, and because the law does not require the record of location notices and assessment work to be made in the Land Department there is an apparent tendency at present to attempt to acquire a control of timber land, waters, and power sites on nonmineral lands, through alleged placer locations, to monopolize the same, and to maintain possession and continue to use the same without payment to the United States of the amounts contemplated by law within a reasonable time.

PUBLIC LANDS CONTAINING DEPOSITS OF COAL.

By T. J. Butler,
General Land Office.

The act of March 3, 1873, provides for the disposal of the public lands of the United States containing valuable deposits of coal. Under its provisions every person above the age of 21 years, who is a citizen of the United States, or who has declared his intention to become such, or any association of persons each member of which is a citizen of the United States above the age of 21 years, or has declared the intention to become such, has a right to enter any quantity of vacant coal lands of the United States not otherwise appropriated or reserved, not exceeding 160 acres to such individual or 320 acres to such association of persons, upon payment of not less than $10 per acre for such lands where the same are situate more than 15 miles from any completed railroad, and not less than $20 per acre for such coal lands as shall be within 15 miles of any completed railroad, or if such association consists of not less than four persons, and shall have expended not less than $5,000 in the development of the mine, it may enter a maximum of 640 acres.

Under the present holding of the department, and of the courts, only lands that contain a deposit of coal possessing commercial value may be entered under said laws. The theory of the law is that the prospective entrymen will open up a mine such as will demonstrate the value of the land as a coal proposition. No means has been provided by the Government for ascertaining whether or not each particular legal subdivision contains a valuable deposit of coal, further than the geological deductions from known facts, such as outcrops, or mines upon veins in the vicinity of the particular tract in question, and, as in many instances, lands which contain valuable deposits of coal are valuable for agricultural purposes or for the timber they contain, great confusion has resulted in the classification of such lands.

Less than 500,000 acres of the public lands have been disposed of by the Government as coal lands and patents issued under the coal-land laws. It will be admitted that the area disposed of since the enactment of the law in 1873 is very small as compared to the entire area of public land containing valuable deposits of coal. This results from other reasons as well as from the difficulty in the classification of the lands, and is due, in a large measure, to the fact that under the present law, only 160 acres of land may be acquired from the Government by the individual, while the maximum for an association of not less than four persons is 640 acres. It is conceded that the area allowed to be acquired by entry is, as a rule, too small to justify the great expenditure required in the opening up and successful development and operation of coal mines. Those possessed of the means of developing lands of this character would not be warranted in investing the sums that would be required in such development, and the production of coal, and to place it upon the market unless they were permitted to acquire a sufficient quantity of lands as a basis of their operation to render their investment a permanent one. As a result the tendency has been for persons and associations, who make entries and acquire patents to lands under the coal-land laws, to sell the same to corporations or large companies who develop them more with a view to the financial prosperity of the operators than to the interest of the public, and as the process of equipping the mine is expensive, it would be an impracticable and unwise investment if the area permitted to be entered were so limited as to make exhaustion within a short time certain.

Frequently coal deposits appear upon the surface of the land, which, if opened up by excavation into the side of the mountain where they appear, are, at a short distance from the surface, valuable deposits, while at the surface, and for a considerable distance beneath it, by reason of disintegration, the coal is of little value; and the individual who is led by the appearance of the coal on the surface to make entry of the land on which it appears finds that he has reached the limit of the land embraced within his entry before he has removed the disintegrated and valueless coal and reached the deposit that is of actual value.

Under the present law, if the land contains a valuable deposit of coal, which may be found at a great depth beneath the surface, and at the same time is of great value for agricultural purposes, or for the timber it contains, the fact that it contains such a deposit of coal prevents the home seeker from acquiring the surface as a home, or the investor from developing the timber product. In sections of the public-land States there are vast areas, frequently several townships in extent, which are underlaid with valuable deposits of coal, and the surface of which is fertile and productive and of great value for agricultural purposes. A large part of these lands has been settled by actual settlers in good faith who have constructed valuable improvements, with the purpose of establishing permanent homes, but it having become known before title was earned by the settler that such coal deposits exist upon the land, the Government has been compelled to cancel these entries at great loss and injustice to the settlers, and with no gain to the Government or anyone else; or, if patent issued before the deposit became known, title to the coal deposits as well as to the surface of the land was, by the issuance of the patent, divested from the Government and vested in an individual who found it impracticable to develop the resources which his land contained. As a result, the coal field either remains undeveloped or an intended monopoly steps in and acquires from the individuals the coal rights covering the entire field, which rarely results in a development for the best interests of the public.

It also frequently occurs that lands contain such a deposit of coal as may be profitably mined, and at the same time are of greater value for agricultural purposes. Under the present law, it is not necessary that the coal deposit be of sufficient quantity and merchantable quality to render the land more valuable for coal as a present fact than for other purposes, in order to render it not subject to entry under the homestead or other agricultural laws, but it is sufficient to prevent agricultural entry if the land contains a deposit of coal possessing a commercial value. The Land Department now finds itself confronted with a situation something like this: There are now pending before the General Land Office approximately 5,000 homestead entries in support of which final proof has been submitted, and it conservatively may be estimated that an equal number of homestead entries where proof has not been made embrace lands that have been reported by the United States Geological Survey as coal lands.

As instances of this character, the coal fields of North Dakota, which to a great extent underlie a practically level or gently undulating fertile plain, and the Raton coal field in northern New Mexico may be cited. In the North Dakota fields there are many localities where mines have been opened up showing a vein of good lignite coal 6 or 8 or 10 feet in thickness. These mines frequently are located on lands 8 or 10 or as far as 16 miles from the Missouri River, and the veins of coal have not been opened between such mine and the river, but the government geologists, who have made examinations of these lands, have been compelled to classify all the lands between the river and such coal mines as coal lands for the reason that the same vein of coal, or what appears to be the same vein of coal, is visible in the banks of the river. This intervening space of from 4 or 5 to 16 miles in width is almost entirely occupied by settlers who have made entry for the land as homesteads.

Many of these homesteaders have resided upon their farms for from five to seven years; have built comfortable houses and other improvements, in some instances of a value of from $1,500 to $2,000, and cases have come under my notice where improvements valued at $3,000 and even more have been made by such homestead entrymen, with a view to obtaining title to the lands from the Government under the homestead law. The situation in the Raton coal field is quite similar. In that field the deposit of coal consists of several veins varying in thickness from a few inches to approximately 7 feet. The coal is of excellent quality, and is said to be one of the best steam-producing coals that has been discovered in the United States. These deposits are found in blanket veins, which outcrop in the side of the mountain at approximately 1,000 feet below the top of the mountain. The top of the mountain is a flat mesa from 1 to 5 or 6 miles wide, and is covered with a growth of grass sufficient to render it valuable for grazing purposes, or where under cultivation abundant crops are produced. This mesa has been taken up by homesteaders, who have established comfortable homes and a prosperous and substantial community differing from the coal fields of North Dakota, in that patent has issued, and these homesteaders have practically all received title to their lands.

While the issuance of patents protects the interests of the individual in his improvements upon the land and his right to the use of the land and the coal it contains unless fraud is shown, still the fact remains that the Government has divested itself of all title to, interest in, or control over the valuable deposits of coal which underlie the patented land. In neither of these instances can the settler be charged with actual knowledge of the coal character of the lands which he has selected. There are no outward appearances upon his land or in the immediate vicinity thereof that would charge one not a geologist, or without considerable acquaintance with geological formations, with knowledge of the presence of coal upon such lands. The settlers have gone upon the land innocently without intention of violating the law, in pursuance of the natural home-making instincts, and after having performed all that the Government requires of them under the homestead law, the Government has found itself unable to protect them in their rights to their improvements and the use of the surface of the land, as there is no provision of law whereby title to the surface of the land may be granted without granting title to all that lies beneath the surface.

Under the present land laws no provision is made whereby the Government may develop the natural resources of its own land. In order to render these resources available the Government must divest itself absolutely of all title to the land and the deposits of coal which it may contain, nor has the Government any power under which it may, after it has divested itself of the title to the land, prevent the lands from being brought under the control of a monopoly, and either withheld from development or being developed in a wasteful manner. It thus happens that interests which own lands upon which are operating coal mines in one section of the country acquire control of other coal fields and prevent the development thereof, because they deem it of financial benefit to themselves that the coal from this other field should not be placed upon the market and made available for public use. It, of course, is unfair and unjust to the community where such undeveloped coal fields lie to be compelled to purchase the product of a distant field and pay transportation expenses.

Besides all these defects in the law as it now stands there is what, from the standpoint of public policy, is greater and of more importance than any or all of them—that is, the absolute lack of provision whereby the Government can conserve its coal resources or in any manner regulate their development. Under the present law, when the Government parts with title to the land, the private parties may conduct their operations in such manner as they see fit, and may entirely exhaust the deposit if it seems best for their financial interest that they do so. They may operate their mines in such manner as to take out only the heart of the vein, which is of the very best quality, while large quantities of coal possessing utility are either permitted to remain in the ground or to waste upon the dump at the mine opening. It is a fact of common knowledge, and it is necessarily so, that under the present law this great natural resource is simply a subject of speculation, dependent upon the present exigency of opportunity for financial gain and with no concern for the future.

The development and production of coal is conducted entirely without concern as to the coal supply for the future. The result has been that in many sections of the country the coal supply already is becoming depleted, and in some cases has been exhausted and the mines abandoned. In this connection, when I say the supply has become depleted or exhausted, I do not mean as to the physical presence of the coal, but as a profitable investment the operation of the mines is not sufficient inducement to withdraw the necessary capital from other channels of trade. Under the present law, if an applicant is qualified to make a coal entry and acts in good faith and complies with the requirements of the law, he can not be refused patent, and when patent issues, under such circumstances, the Government divests itself absolutely of further control over the coal deposit or the development thereof. No matter what waste may be committed, nor to what extent the public may be deprived of the use of this great resource, the Government can not, except under its police power, interfere with the right of dominion over his property exercised by the individual.

THE DESERT LAND ACT.

By W. B. Pugh,
General Land Office.

It is difficult if not impossible to conceive that Congress, when it framed and enacted the acts of March 3, 1877, and March 3, 1891, which contain what we commonly call the law of desert-land entries, did not have in contemplation the beneficent results incident to a complete and permanent reclamation of the arid public lands as distinguished from a partial and temporary achievement in that direction. And I think it will, as it must, be conceded that such was the object and the hope of the lawmakers, for, as reformation is never of any value save as it is effectual and durable, so would reclamation of waste and desert areas be useless and unprofitable if subjugation is to be only for a time, after which the desert is to return with all its incidents. Temporary reclamation is nothing but a casual suspension of natural conditions, and without continuing means of and provision for irrigation a reclaimed desert would soon relapse into its former state of aridity and barrenness.

The law intends, and expressly demands, that as a condition precedent to the acquisition of title to desert lands, the individual who seeks the benefit of its license shall perform and prove actual and absolute reclamation of the whole area of the entered land. There is no qualification, in the language of the law, as to the extent or degree of successful achievement, but a plain and unequivocal requirement of full and complete redemption. The letter of the law does not authorize any disposition thereunder of one solitary acre of unreclaimed lands, but the Interior Department, charged with administration, has very properly construed its provisions in such manner and to such effect that, where it is satisfactorily shown that there are included scattered areas too high or too stony to admit of successful and practicable irrigation, failure to carry water onto those areas will not defeat an application for patent. By way of taking some security for the future the law has been held to require that as a means to permanent irrigation the entryman shall possess, in his own right and by an absolute title, the right to the use of water sufficient for the irrigation of all of the irrigable land included in his entry; and, by way of providing for irrefragable and indisputable evidence that the grasp of the desert has been broken and cast off, it is required that at the end of four years the entryman shall prove that he has successfully cultivated at least one-eighth part of the land he has undertaken to redeem.

Having laid this premise as to the spirit and the purpose of the law, as evidenced by the several specific provisions or constructive requirements thereof to which I have alluded, I shall now make a few suggestions as to the practical workings of the law as I have had opportunity to observe them in the field.

First. It is manifest that, apart from those evils to which the operation of every public-land law is subject, which have their origin in craft and cunning and guile, and which tend to defeat the design of the law, the administration of the desert-land law is subject to abuses which may be deemed special and peculiar. In the short space allotted to me I can only direct attention to two or three of the principal of these abuses. What seems to be a very serious evil, and one commonly met with in practice, may be ascribed to the failure of the law itself to fix and prescribe any minimum of irrigable and irrigated area, out of a total area entered, which will entitle the entryman to patent. As I have previously pointed out, the department, considering that Congress must have known and had in mind when it enacted this law that nearly every desert-land entry would embrace some small spots or parcels of ground which could not be irrigated without resort to expenditure greater than any possible value those particular parcels would possess in a reclaimed condition, has so administered the law as not to require proof of the irrigation of such small parcels. As to such included areas the only requirement of proof is that it shall be shown that reclamation is impracticable. But the department has not prescribed, and can not establish, any engineering standard by which to determine the practicability or impracticability of irrigation to which resort may be had in all cases, and must manifestly accept the statement of the claimant and his proof witnesses concerning such an alleged condition; and it is more or less obvious that the determination of what is and what is not practicable in irrigation is, as it must be, left largely to the conclusion of the claimant and those who testify in support of his claim.

The proof usually submitted in support of such a contention or conclusion is wholly nonexpert and unprofessional and is generally extremely simple and indeterminate in character and probative tendency. As a result of this want of fixed limitation and in the absence of any standard by which to measure practicability of irrigation, desert-land entries for 320 acres of land very frequently pass to patent upon proof showing reclamation of only 40 or 45 acres; and in passing it may be suggested that even this slight modicum of achievement is often of doubtful value. While serving in the field I have often had my attention directed to desert-land entries on which patents had been granted of the lands of which only a small portion had been irrigated. It required only a casual examination to create the conviction that the expenditure of some very small sum of money in addition to what had been expended, or the exercise of some greater intelligence or care in the choice of a location for the diversion dam or reservoir, would have resulted in an important increase in the irrigated area. The impression created in my mind, as the result of what I witnessed of the operation of the desert-land law, is that it is too frequently the case that the entrymen of such lands desire to secure them only for pasture for cattle, for which purpose they would provide a sufficient growth of grass without irrigation, and that reclamation is only a fiction, or perfunctory sort of process, necessarily preceding application for the legal title. It is also true that the entryman, when he comes to determine what portion of the entered lands it is practicable to irrigate, does not always have in mind the test of practicability described by the department, to which I have previously alluded, but rather refers to the state of his purse, or his willingness to make the expenditure necessary for reclamation of a larger area.

Second. The water rights relied upon are too often so precarious, or so utterly without merit, as to hardly deserve the title. Very frequently do they depend upon mere surface-water drainage, accumulated in or by a dry draw, coulee, or arroyo and conserved in a reservoir created by constructing a dam across the coulee at the place of ultimate impounding.

While appropriation of surface water is sanctioned by the laws of some of the States, it is more or less difficult, if not impossible, for the legal mind to clearly perceive how such an alleged right can possess either of the essential elements of permanency or absolutism, except and unless the entryman owns the drained area or has some contract right by which he may forever demand unobstructed flow of the surface waters. By surface waters I mean, of course, the waters resulting from rains or melting snows. If he has no such title or contract right, it seems more or less clear and certain, as a legal proposition, that, however such a right, or alleged right, may have the support of state legislation, the claimant under it can not hope to so enforce his claim against the United States, or against their grantees of the lands within the drained area, as to charge those lands with the burden of forever serving as a mere dripping pan for the benefit of his lands. On the contrary, it might seem reasonably well settled that the legal owners of such drained lands may employ them in agricultural uses or other lawful ways without regard or concern for such consequential interference with, or absorption of, the surface waters as will practically destroy the right of the alleged appropriator.

Third. As now ordered and provided by the law of most of the several States and Territories, a water right is not appurtenant to the land upon which it is employed, in the sense that it can not be severed; as a consequence, the same right is made use of for the temporary reclamation of several different tracts of public lands claimed by different entrymen, one of these exercising it only long enough to enable him to make the proof required by law, whereupon he transfers it to some other claimant, who would not otherwise be able to secure the use of water, owing to the prior appropriation and often overappropriation of all of the available water. It is a manifest consequence of this condition that there are, in many localities where this practice obtains, large areas of land appropriated under the desert-land law, for the permanent reclamation of which there is no possible source of water supply. It is a common experience to find that there are large quantities of land with whose title the Government has parted under the desert-land law and as to only a very small portion of which has the real and essential purpose of the law been secured. I may properly say that I have traveled through localities in which more or less extensive areas of lands had been disposed of under the desert-land law, and a most critical inspection failed to reveal the slightest evidence that these lands had ever received any treatment different from that to which the yet unappropriated public lands in the same localities had been subjected. Yet I had no reason to doubt, and, in fact, inquiry led to the conviction, that the letter of the law had been complied with, with perhaps some slight evasion and some slight coloring of proof. The situation I observed was simply due to the fact that the entrymen of these lands had not, at the time of original entry, entertained any purpose to permanently maintain the condition of reclamation which they might produce; acquisition of legal title had been followed by concentration of ownership and subsequent abandonment of all irrigation instrumentalities. Lapse of time and the trampling of cattle, to the pasturage of which the lands had become devoted, completely effaced all evidences of ditches and all other means or results of irrigation.

There are other evils of which I might give some illustration if my title to your further patience were greater, but those which I have tried to delineate seem to me to be the most serious, as considered apart from those which are the result of pure fraud and unscrupulous and purposeful violation of the law.

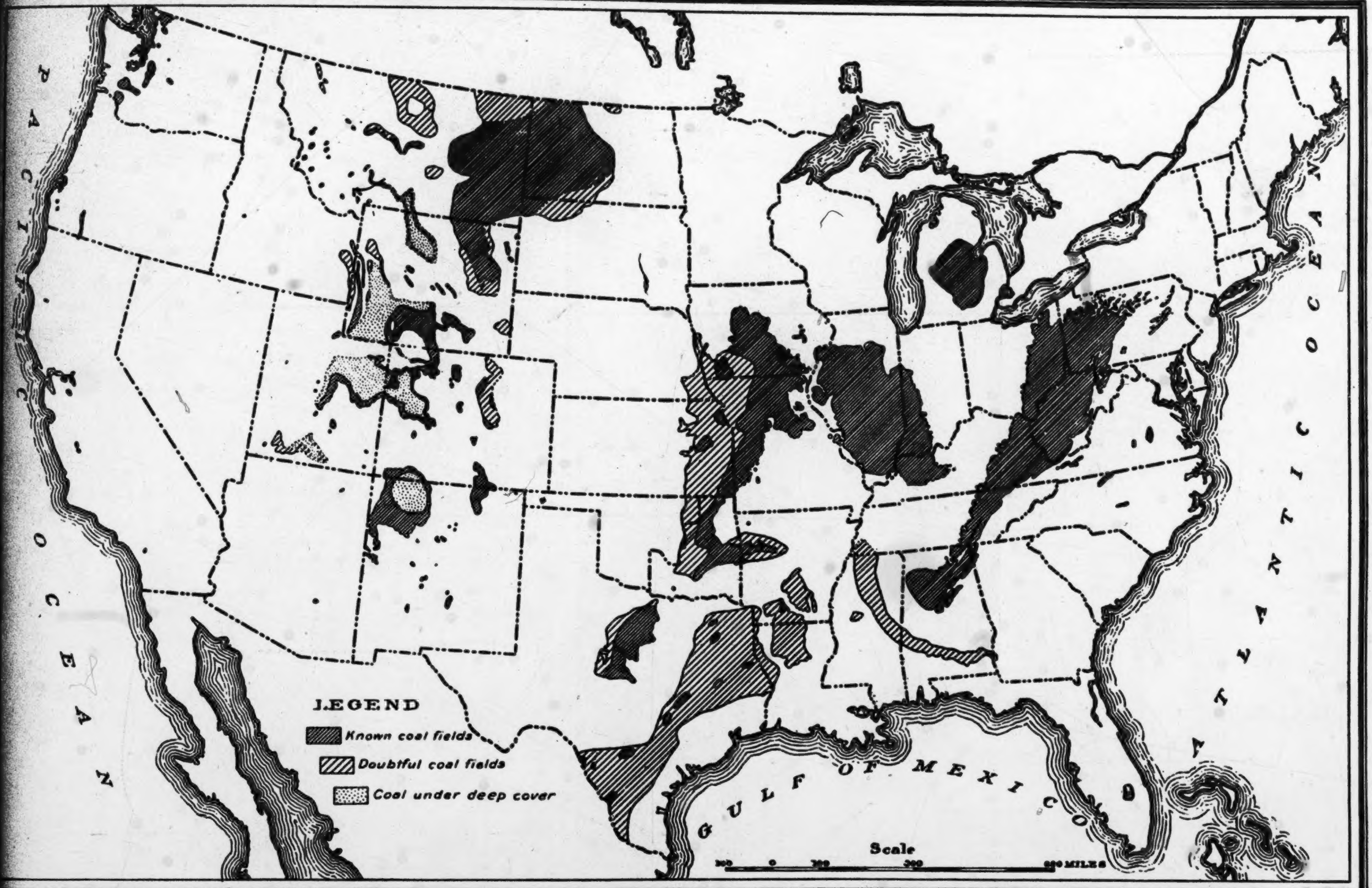
COAL FIELDS OF THE UNITED STATES.

By Marius R. Campbell and Edward W. Parker,
United States Geological Survey.

According to the estimates prepared by the U. S. Geological Survey, the area underlain by workable coal beds in the United States is 496,776 square miles. Of this total area, 480 square miles contain the entire anthracite coal fields of Pennsylvania. The bituminous coal fields are estimated to be contained in an area of 250,051 square miles. The grade of coal between bituminous and lignite, which is designated by the Geological Survey as "subbituminous," is estimated to be contained within areas aggregating 97,636 square miles, while the areas containing lignite aggregate 148,609 square miles. The coal fields are divided, for the sake of convenience in classification, into six main provinces, as follows:

1. The eastern province, containing the anthracite coal fields of Pennsylvania and the bituminous coal fields of the Appalachian region, i. e., those of western Pennsylvania, Ohio, Virginia, West Virginia, Kentucky, Tennessee, Georgia, Alabama, and small outlying areas in North Carolina.
2. The interior province, containing the bituminous coal-producing regions of Michigan, Illinois, Indiana, western Kentucky, Iowa, Kansas, Missouri, Oklahoma, Arkansas, and Texas.
3. The Gulf province, containing the lignite areas of Alabama, Mississippi, Louisiana, Arkansas, and Texas.
4. The northern Great Plains province, containing the lignite subbituminous areas of North and South Dakota, eastern Montana, and northeastern Wyoming.
5. The Rocky Mountain province, containing the bituminous and subbituminous areas of western Montana and western Wyoming, Colorado, Utah, and New Mexico.
6. The Pacific coast province, containing the areas of Washington, Oregon, and California.

During the last few years the Survey geologists have worked in all of these coal areas and have also been making careful estimates of the quantity of coal contained in the beds when mining first began. In making these estimates care has been taken to ascertain how much of the supply is easily available and how much is either not available under present mining and market conditions or is available with extreme difficulty. According to these estimates the quantity of coal contained within the known area of the United States when mining first began was 3,076,204,000,000 tons. Of this quantity a little less



PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
LEGEND
▨ Known coal fields
▨ Doubtful coal fields
▩ Coal under deep cover
Scale
100 0 100 300 600 MILES

DISTRIBUTION OF COAL FIELDS IN THE UNITED STATES.

n two-thirds, or 1,922,979,000,000 tons, is considered as coal that ily accessible or minable under present conditions, while slightly than one-third, or 1,153,225,000,000 tons, is considered as non-ble under present conditions or accessible with extreme difficulty. hould be remembered, however, that the quantity of coal given as easily accessible includes the lignites and subbituminous of the Western States, of which approximately 530,000,000,000 , while easily accessible, can not be considered available under nt conditions or those which may be expected in the near future. would reduce the original supply of easily accessible and avail- coal to approximately 1,400,000,000,000 tons.

The area of the different provinces and the quantity of coal con-ed therein when mining first began are shown in the following le:

Tonnage (short tons), by provinces and accessibility.

[Original coal supply.]

Province.	Area in square miles.	Amount easily accessible.	Amount accessible with difficulty.	Total.
rn	70,022	555,634,000,000	8,000,000,000	563,634,000,000
rior	144,664	406,667,000,000	91,000,000,000	497,667,000,000
	84,300	13,045,000,000	10,045,000,000	23,090,000,000
rn Great Plains	103,564	521,793,000,000	459,000,000,000	980,793,000,000
y Mountains	92,396	414,740,000,000	574,280,000,000	989,020,000,000
coast	1,830	11,100,000,000	10,900,000,000	22,000,000,000
Total	496,776	1,922,979,000,000	1,153,225,000,000	3,076,204,000,000

The distribution of this original supply of coal, according to grades d accessibility, is shown in the following table:

Tonnage (short tons), by grades of coal and accessibility.

[Original coal supply.]

Kind of coal.	Area in square miles.	Amount easily accessible.	Amount easily accessible and available.	Amount accessible with difficulty.
hracite and bituminous	250,531	1,176,727,000,000	1,176,727,000,000	505,730,000,000
bituminous	97,636	356,707,000,000	216,252,000,000	293,450,000,000
ite	148,609	389,545,000,000		354,045,000,000
Total	496,776	1,922,979,000,000	1,392,979,000,000	1,153,225,000,000

The first mining of coal in a commercial way, in the United States, as in what is known as the Richmond basin, a small area in the stern part of Virginia. Small quantities of coal had been mined re in the latter part of the eighteenth century and it was also in e latter part of the eighteenth and the beginning of the nineteenth nturies that efforts were being made to introduce anthracite coal for el purposes. The first actual records of the production of Virginia al were in 1822, in which year it was reported that 54,000 tons were ined. In 1820 (two years before) 365 long tons of anthracite coal, r 1 ton for each day of the year, had been shipped to distant mar-ets. From these small beginnings of less than a century ago the production of coal has increased until in 1907 the total output of anthracite and bituminous coal approximated 500,000,000 tons. In 1837 the total production of the United States reached, for the first time, a total exceeding 1,000,000 tons, the output being reported from 4 States only—Pennsylvania, Virginia, Kentucky, and Illinois—although Maryland also was producing a small quantity of coal at that time. In 1840 the production amounted to a little over 2,000,000 tons, the output being reported from 13 States. Ten years later, in 1850, the production amounted to 7,000,000 tons; in 1860 it was over 14,000,000 tons; in 1870 over 33,000,000 tons; in 1880 over 70,000,000 tons; in 1890 it approximated 160,000,000 tons; in 1900 it was nearly 270,000,000 tons; and in 1907 it was 480,000,000 tons. The aggregate production to the close of 1907 has amounted to 6,865,097,567 short tons.

Up to the close of 1845 the total production of coal in the United States was 27,700,000 short tons, and since that time the drain on the supply has practically doubled with each decade. The total production to 1845 and decennially since that time has been as follows:

	Short tons.
Up to 1845	27, 677, 214
1846–1855	83, 417, 827
1856–1865	173, 795, 014
1866–1875	419, 425, 104
1876–1885	847, 760, 319
1886–1895	1, 586, 098, 641
1896–1905	2, 832, 402, 746
1906–1907	894, 520, 702
Total	6, 865, 097, 567

It is estimated that for every ton of coal mined and sold, half a ton is lost or wasted, so that the total production of 6,865,097,567 short tons to the close of 1907 represents an exhaustion of 10,200,000,000 tons, or 0.3 per cent of the total original supply, or 0.7 per cent of the coal which is easily accessible and available under the present conditions. The total supply of easily accessible and now available coal left in the ground at the close of 1907 was 1,382,780,000,000 short tons.

Accompanying this statement two charts are presented, one showing the production of coal annually from 1846 to 1907, the other illustrating the average annual production by progressive ten-year periods for the same length of time, the latter chart having been prepared in order to eliminate minor variations due to abnormal conditions. The average annual increase in coal production figured from the average of progressive decades shown on the second diagram is 7.36 per cent, and for the last five progressive decades—1894–1903 to 1898–1907—the rate of increase has been above that average.

DURATION OF SUPPLY.

The total reserve of easily accessible and now available coal is estimated at 1,382,780,000,000 tons. The assumption that a constant output has been reached would be utterly unwarranted. On the other hand, the adoption of the flat rate of annual increase of 7.36 per cent would involve the improbable assumption that the marvelous record of the past and present will be maintained in the future and the production would continue to approximately double every decade. Using the waste allowance, on the basis of this constant rate of increase in production, the 1,382,780,000,000 tons available at the close of 1907 would be exhausted in one hundred and seven years, or by 2015 A. D. Against the use of the flat rate of increase it may well be contended that just as the rate of increase in population tends to diminish, so this rapid increase in per capita consumption of coal can not persist, and a constant annual production will be reached. However, the figures set fifty years ago by statisticians for the probable constant annual production of coal in England have already been exceeded by over 160 per cent.

Mr. Henry Gannett has made an estimate based upon a decreasing rate of increase calculated from twenty-year averages of production. The use of ten-year averages is regarded as unsatisfactory for the reason that one of the decades may consist mainly of a period of prosperity, while the preceding and succeeding decades contain periods of business depression. The twenty-year period, however, is sufficiently long to include a period of prosperity with one of business depression. Taking the four twenty-year periods since 1828, three rates of increase are obtained which show a rapid decrease. The hyperbolic curve computed from these successive rates of increase will indicate the constantly diminishing rate of increase for the successive twenty-year periods. The result obtained by this method is that the easily accessible and available coal will be exhausted about the year 2027, and all coal by the middle of that century. It is recognized that the data upon which this curve has been constructed are few and the curve correspondingly weak. However, in the above estimate all of the data have been given which it is possible to use, and this estimate is believed to represent the best use that can be made of the data at hand.

100 yrs

Inasmuch as America leads the world not only in present production of coal, but also apparently possesses the greatest reserve and certainly is mining coal at much lower cost than any other country, the obvious tendency will be for European countries to look more and more to the United States for their coal supply. Therefore, while our present coal production and consumption are practically equivalent, the export of coal, unless prohibited by federal legislation, must eventually become a factor and increase the coal production in the United States beyond the demands of home consumption. On the other hand, powerful influences will come to bear upon coal production, which favor lengthening the life of the supply. Thus it is to be hoped that with more improved methods in the utilization of coal the increased efficiency per unit may act as a factor in reducing coal consumption, and improved mining methods should likewise decrease the waste percentage. The increased utilization of water power should also tend to decrease coal consumption. Again, as soon as the end appears in sight prices will rise and production diminish, and that progressively. This interference with the law of decreasing increase produced by growing scarcity will, of course, prolong the life of our coal reserves, but at the same time will greatly hamper our industries that depend on this fuel.

With so many indeterminate factors whose importance is realized but can not be measured, prophecy must possess a questionable value.

WASTE IN COAL MINING.

The principal loss or waste attending coal-mining operations is that represented by the quantity of coal necessarily left in the ground as pillars to support the roof. In some cases it is also necessary to leave a foot or more of coal as a part of the roof, because of the unstable character of the material overlying the coal, which itself does not make a good roof. It has also been frequently the case that, where portions of the coal bed have been of inferior quality, only the high-grade coal has been mined and the poorer material left. The coal left as pillars, or as portions of the roof, may be considered a necessary loss, but that which is left because of its inferior quality can not be considered unavoidable waste in any sense, and is frequently of higher grade than coals mined and used in other portions of the country.

Enormous quantities of coal have been lost beyond recovery from the mining of beds lying below, the caving of which, upon the withdrawal of the pillars, has so broken up the overlying strata as to render it impossible to recover the coals contained therein. This has been particularly the case in some of the coal beds of western Pennsylvania, but much improvement has been observed in this regard within later years. Notwithstanding the improvement in this respect it is probable that a large amount of coal will be wasted in the Western States, where a great number of coal beds are closely associated, and also where the intercalated strata are weak, forming poor roofs to the mines.

There are no exact figures as to the actual loss or waste sustained through coal left in the mines in conducting the mining operations, but it has been estimated that it amounts to 50 per cent of the quantity produced and marketed. In some cases, through careful mining and where the conditions are ideal for working, practically all of the contents of the coal beds are recovered. In other cases, particularly when the beds are of enormous thickness, the recovery has not exceeded 30 per cent of the contents. During the earlier days of mining in the anthracite regions of Pennsylvania it was estimated that only 40 per cent of the coal was marketed. This was partly due to uneconomical methods of mining, and partly to the large amount of culm, for which there was at that time no market and which was piled on the ground in unsightly mountains. At the time of the Anthracite Coal Waste Commission, which made its report in 1893, 40 per cent was still considered a maximum recovery. So far as underground workings are concerned, there has been no revolution in the methods employed since that time, but there has been a considerable improvement in the application of those methods, which has resulted in the recovery at the present time of a materially larger proportion of the coal in the ground than was the rule at that date. The earlier methods of mining consisted in leaving comparatively narrow pillars, and in the mining of large rooms the the result was that the pillars were not strong enough to stand the pressure and were crushed beyond recovery. It is now customary to use larger pillars between the rooms, which makes it possible to better control the roof during " robbing " operations and to eventually recover a larger proportion of the contents of the bed.

Material improvements have also been made in the methods of the preparation of coal, so that a much greater proportion of the product hoisted is now being sent to market in merchantable condition. Part of this is due to better and more systematic methods of handling, and part to the saving of small sizes which formerly went to the culm banks. The higher prices of coal and the development of methods for using these small sizes have also made it possible, through washing processes, to rework the small coal formerly thrown on the culm banks, and these are now furnishing several millions of tons of marketable coal annually.

Under present conditions, except in cases where the surface must be maintained, it is estimated that in the Wyoming region of the Pennsylvania anthracite field the recovery for market is from 60 to 64 per cent. In the Lehigh, Mahanoy, and Schuylkill regions the recovery for shipment is estimated at 56 per cent.

When the Anthracite Coal Waste Commission[a] made its report in 1893 the shipments of anthracite had amounted to 820,362,995 long tons, and the total production was estimated to have been 902,000,000 long tons. The commission estimated that for every ton produced, 1½ tons were lost, and the total exhaustion was estimated at 2,255,000,000 long tons. The estimated original contents of the field were 19,500,000,000 tons, and the estimated contents remaining at the beginning of 1893 were 17,245,000,000 tons.

The commission in its report (p. 149) says:

> It is to be doubted whether the total coal won when the field shall be abandoned will exceed 40 per cent of the total contents. An estimate on that basis would show the available marketable coal still now in the ground to be as follows:

	Tons.
Wyoming region	1, 859, 000, 000
Lehigh region	477, 500, 000
Schuylkill region	4, 561, 500, 000
In all	6, 898, 000, 000

> The amount of coal won at the modern colliery due to improvements in mining methods, in the appliances for handling the coal, and in the utilization of the small sizes shows a decided advance over the earlier years of mining; a still further advance will undoubtedly be made in these directions, and the mining of the small beds, where a larger per cent can be won, will all tend to increase the total. Future estimates for a long time will in all probability show an advance in the total per cent won.

What the commission predicted in the foregoing paragraph has to some extent already been accomplished, from the fact that coal is now being mined from beds that were not considered a part of the available reserves when the commission made its report. In mining methods, as previously stated, there has also been a marked improvement, and the writers are of the opinion that it is safe to assume that since 1893 the 1 ton of coal lost for every ton mined is nearer the actual results than 1½ tons lost for each ton mined, and at this rate the available supply at the beginning of 1893 would have been 8,622,500,000 tons instead of 6,898,000,000 tons. The total production from 1893 to the close of 1907 has amounted to 833,187,445 long tons, which deducted from the estimated available supply of 8,622,500,000 tons would leave as the remaining available supply 7,789,312,555 long tons, it being understood that this is only one-half of the coal left in the ground untouched. What may be done in the future in the way of recovery of coal which is now considered an absolutely necessary waste and lost for all time is, of course, a matter of conjecture.

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[a] The members of the commission were Eckley B. Coxe, of Drifton; Heber S. Thompson, of Pottsville; and William Griffith, of Scranton, Pa.

In the mining of bituminous coal it is estimated that for every ton of coal produced for market one-half of a ton is lost or wasted. The part of this which is represented by the coal left in the mines for pillars, etc., may be materially reduced, but in many cases the recovery of a larger percentage of the coal in the ground can be obtained only by an increased cost of mining; and this in the face of the overdeveloped properties, keen competition, and low selling prices is incapable of accomplishment at the present day unless there be concerted legislative action by the governments of the several States.

There is another and a serious loss or waste in bituminous coal mining which is, like the culm in the anthracite fields, represented by the slack or fine coal necessarily or unnecessarily produced in mining operations. This is particularly the case when the coal is of the "dry" or noncaking variety which can not be used for coke making or which, because it does not fuse in the fire box, fails to make a satisfactory steam fuel. Many thousands of tons of this "slack" coal are thrown on the ground each year, and much of it is burned in order to prevent it from "cumbering the ground" or adding extra weight above the mine workings. A large part of this waste could be prevented by briquetting, but the process of briquetting adds about $1 per ton to the cost of the fuel, which renders competition with cheap fuel in the shape of raw coal impossible. Two of the causes which lead to the production of unnecessarily large quantities of slack are the excessive use of powder and the practice of "shooting from the solid." These reduce the percentage of large-sized or marketable coal and naturally increase the cost of that portion of the product.

Legislation prohibiting shooting from the solid, which would provide penalties for excessive use of powder, would have as one result a larger percentage of lump coal; and thus in a measure enable operators to assume the additional expense involved in the briquetting of such slack coal as is unavoidably produced.

This legislation is the province of the state governments, and it is not too much to hope that before long laws may be enacted against the accumulation of slack heaps or their useless destruction by burning, and this waste prohibited, as that of natural gas has been in some cases.

The question of the waste in the combustion or utilization of coal does not come within the scope of this paper, but as the manufacture of coke is, in reality, a preparation of the fuel for use, attention may properly be called to the enormous waste resulting from beehive oven practice (the method commonly employed in the United States).

In what is known as the beehive oven (so called because of its similarity in shape to the conventional beehive) the coal is partially consumed, or, more properly speaking, the volitile combustible contents are consumed and all of the valuable constituents of the coal, except the fixed carbon, which is left behind as coke, are wasted. These wasted constituents consist of gas, tar, and ammonia. In what are known as by-product recovery ovens, however, the process is one of distillation and the by-products of tar and ammonia and all of the gas, except that used for heating the ovens, are recovered and used.

The United States is far behind Germany and other foreign countries in adopting the economies resulting from the coking of coal in by-product ovens. In Germany at the present time little or no coke is made except in retort ovens. The first ovens of this type in the United States were built in 1893 at Syracuse, N. Y. Up to the close of 1907 the total number of this type of ovens completed was 3,892, while the number of beehive ovens in operation in that year was 94,746. The production from the retort ovens was 5,607,899 short tons of coke and that from beehive ovens 35,171,665 tons.

When the economies which may be effected by the use of the retort ovens have been so clearly demonstrated, not only by the plants which have been constructed in the United States, but more emphatically through the much more extensive development of by-product coke manufacture in Europe, the condition in the United States, as shown by the statistics for the last four years, is somewhat difficult to understand. As previously stated, the production of coke in the by-product ovens of the United States in 1907 amounted to 5,607,899 short tons. It was valued at $21,665,157. The total value of by-products obtained in the manufacture of this coke was $7,548,071, this value and the quantity being distributed as follows:

Value of by-products obtained in manufacture of coke in retort ovens in 1907.

	Quantity.	Value.
Gas .... thousand cubic feet..	20,516,731	$3,130,839
Tar .... gallons..	53,905,795	1,242,530
Ammonia, sulphate or reduced to equivalent in sulphate .... pounds..	125,372,360	3,174,702
Total	....	7,548,071

The gas included in the foregoing statement is the "surplus" not consumed in the coking process and is either sold or used at manufacturing establishments operated in connection with the coke-oven plant. In a few instances where the surplus gas is consumed by the producing companies the quantity is not measured, nor was any value placed upon it in the reports made to the United States Geological Survey. In such cases careful estimates have been made, based upon the average surplus gas obtained from similar coals used at ovens of the same type. The value, similarly estimated, has been placed at from 10 to 15 cents per thousand cubic feet.

The coal consumed in retort ovens in 1907 amounted to 7,460,587 short tons. The quantity of coal used in beehive ovens was 54,485,522 short tons, from all of which the possible by-products are apparently wasted. Assuming that the coal consumed in beehive ovens was of the same average quality as that charged into the retort ovens and that the prices would be not less than 80 per cent of those ruling in 1907, the value of recoverable products which were thus apparently wasted last year amounted to $44,000,000, a sum equal to nearly 80 per cent of the total value of all the coal used in beehive ovens during the year. At the prices which prevailed in 1907 the value of the by-products wasted in beehive coke ovens was a little over $55,000,000.

The value of the by-products from the retort ovens in 1907 was a little more than one-third the value of the coke produced in them.

It should be remembered, however, that beehive ovens are located in the coal-mining regions and that the cost of the coal charged into them represents only a little more than that represented by the expense of mining the coal, whereas in locating by-product recovery plants provision must be made for utilizing or marketing the by-products. It is for this reason that in much the larger number of cases the recovery plants are established near the larger cities and at considerable distances from the mining regions, and the expense of transportation is added to the mining cost of the coal. Hence it is that the value of the coal charged into by-product ovens in 1907 was $15,874,430, or over $2 per ton, while that of the coal used in beehive ovens was $56,956,008, or $1.05 per ton. It must also be remembered that the original cost of installation for a by-product plant is from four to five times that of a beehive plant of equal capacity. These disadvantages are in turn partly offset by the higher percentage yield of coke in the retort ovens and a lower delivery charge on the coke produced. In the case of beehive coke, railroad transportation expense is borne by the coke, while in retort-oven practice all, or nearly all, of the freight charge is borne by the coal..

The total value of the 5,607,899 tons of by-product coke produced in 1907 was $21,665,157, an average of $3.86 per ton. The value of the 35,171,665 tons of beehive coke made in 1907 was $89,873,969, or $2.56 per ton. If we consider that the difference in the value of the by-product coke and beehive coke was due only to the difference in freight charges, then the total value of the entire product of beehive coke made in 1907 would, if made in retort ovens close to the market, have been $135,750,000. On adding to this the value of the by-products that should have been recovered, amounting to $44,000,000 at 80 per cent of the market price in 1907, the total value of the coke and by-products would have amounted to nearly $180,000,000 instead of the value of $89,873,969 for the beehive coke alone. The value of the coal charged into these ovens, however, would have been $108,879,870 instead of $56,956,008. Carrying the hypothesis further, the difference between the value of the coke and by-products if the coal had been coked in retort ovens and the value of the coke alone from the beehive ovens was, say, $90,000,000. From this should be deducted the difference between what the value of the coal would have been at retort ovens and what it was at beehive ovens, i. e., $52,000,000. The remainder ($38,000,000), less the difference in operating expenses, wear and tear, interest on capital, etc., may be considered as approximately the actual net loss in value as the result of beehive coke production compared with by-product coke practice in 1907.

One of the reasons that has been given for the apparent lack of progress in retort-oven building in the last four years is the lack of profitable markets for the by-products of coal tar, and this has contributed to the backwardness of the United States in the development of the chemical industries depending upon coal tar as a raw material, and yet this country is importing coal-tar products to the value of several million dollars annually. It is also well known that the development of the coal-briquetting industry has been retarded because of the lack of assurance of a satisfactory supply of suitable coal-tar pitch for binding material, and there is also an increasing demand for creosoting oils for the preservation of timber.

COAL SUPPLY, PRODUCTION AND EXHAUSTION, BY STATES.

Alabama.—As far as known the earliest record of the existence of coal in Alabama was made in 1834. The first statement of production is contained in the United States Census Report for 1840, in which year the production is given at 946 tons. In 1907 the production was 14,250,454 tons, and the total production from 1840 to 1907 amounted to 164,734,310 short tons, which represented an exhaustion, including the waste in mining, of 247,000,000 tons. The total coal-bearing area of the State is estimated at 14,430 square miles, and the original coal supply is estimated to have been 68,903,000,000 short tons. The exhaustion to the close of 1907 represents a little over 0.3 of 1 per cent, and the production in 1907 was a little over 0.02 of 1 per cent of the estimated original supply.

Arizona.—A small area of 30 square miles in Arizona is estimated to contain 60,000,000 tons of coal, from which there had been no production at the close of 1907.

Arkansas.—As in Alabama, the first production of coal reported in Arkansas was in the census year 1840, when 220 short tons were reported as having been mined in that State. The industry in Arkansas did not develop rapidly during the early years, as the census of 1860 shows a production of only 200 tons, and that of 1880 a total of 14,778 tons. During the last twenty years, however, there has been a marked increase in the production of coal in Arkansas, and the maximum output was reached in 1907, with a total of 2,670,438 short tons. The total production to the close of 1907 amounted to 23,756,401 short tons, equivalent to an exhaustion of approximately 36,000,000 tons. The estimated original supply of coal in Arkansas was 1,887,000,000 short tons, of which the exhaustion to date represents practically 2 per cent. The production in 1907 was equivalent to 0.15 of 1 per cent of the estimated original supply. The total area in Arkansas which contains workable coal or which may contain workable coal or lignite is estimated to be 7,584 square miles.

California.—The coal fields of California consist of scattered areas, of which, with few exceptions, comparatively little is known. The total workable area is estimated to be 500 square miles, and the original contents of the field 1,000,000,000 short tons. Mining in California had its beginning, according to the records of the state mining bureau, in 1861. The maximum production was reached in 1880, since which time the production has been irregular and has shown a declining tendency, this being due in the last few years to the increased production of oil in the State and its use for fuel purposes. The total coal production to the close of 1907 was 5,030,945 short tons, equivalent to an exhaustion of approximately 7,000,000 tons, or 0.7 per cent of the original supply.

Colorado.—Colorado is one of the Western States which is rich in coal resources. The estimated total area of the coal fields is 17,130 square miles, and the original contents of these fields are estimated to have been 371,770,000,000 short tons. Coal production began in Colorado in 1864, but it was not until 1882 that the output reached as much as 1,000,000 short tons. Since that date there has been a steady increase in production, until in 1907 it amounted to 10,790,236 short tons. The aggregate production to the close of 1907 was 112,668,336 short tons, of which the equivalent exhaustion has been 169,000,000 short tons, which represents a little over 0.05 of 1 per cent of the original supply. The production in 1907 was approximately 0.004 of 1 per cent of the original contents of the fields.

Georgia.—The coal fields of Georgia are limited to a small area in the northwestern part of the State, estimated to cover 167 square miles and to have contained, when mining began, 933,000,000 short tons. The census report for 1860 contains the first authentic statement of production in Georgia, and the output in that year is placed at 1,900 short tons. The production of the State in 1907 was 362,401 tons, and the total production to the close of the year was 8,123,696 short tons, representing an exhaustion of 12,000,000 tons. This would still leave in the ground a total of 921,000,000 tons, of which 650,000,000 tons would probably be considered as the available supply, and this, at the rate of production in 1907, would last approximately 1,800 years.

Idaho.—The areas in Idaho known to contain workable coal are placed at 200 square miles, while there are 1,200 square miles which are not known, but which may also contain workable coal. The estimated original contents of the coal fields of Idaho are placed at 600,000,000 tons, from which to the close of 1907 less than 25,000 tons had been mined.

Illinois.—Illinois is the second State in coal-producing importance. The area in Illinois known to contain coal is larger than that of any other State east of the Mississippi River, and if we consider only the known coal areas the coal fields of Illinois cover a wider area than those of any other coal-producing State. The coal-producing area of Illinois is estimated at 35,600 square miles, and the original contents of the fields are placed at 240,000,000,000 short tons. The earliest mention of coal in the United States is contained in the journal of Father Hennepin, a French missionary, who, as early as 1679, reported a "cole mine" on the Illinois River, near the present city of Ottawa. The earliest record of actual mining is that coal was produced in Jackson County in 1810. In 1833 the production is reported to have been 6,000 short tons. In 1907 it was 51,317,146 short tons. The total production to the close of 1907 amounted to 645,868,309 tons, representing an exhaustion of 968,000,000 short tons, from which it appears that the exhaustion to the close of 1907 has been 0.4 of 1 per cent of the total estimated supply. The quantity of coal remaining in the ground at the close of 1907 was 4,664 times the production of that year, or about 2,500 times the exhaustion represented by that production.

Indiana.—The coal fields of Indiana lie entirely in the southwestern portion of the State. They are confined within an estimated area of 6,500 square miles, and contained, when mining first began, 44,169,000,000 tons of coal. Coal mining in Indiana began sometime between 1830 and 1840, and the census of the latter year reported a production of 9,682 tons. In 1907 the production amounted to 13,985,713 short tons, and the total production to the close of that year amounted to 159,440,390 short tons. The exhaustion to the close of 1907 had been 239,000,000 short tons, or 0.54 of 1 per cent of the original supply. Upon these estimates the quantity of coal remaining in the ground in Indiana at the close of 1907 was about 3,000 times the production of that year, and 2,000 times the exhaustion represented by that production.

Iowa.—The coal fields of Iowa are estimated to contain workable coal aggregating 12,560 square miles. To this may be added 5,640 square miles of possible workable coal areas. The original contents of the fields are estimated to have been 29,160,000,000 short tons. From this there has been produced from 1840, when mining first began, to the close of 1907, a total of 141,608,792 short tons, representing an exhaustion of 212,000,000 short tons. The quantity of coal still available at the close of 1907 was 28,948,000,000 short tons. At the rate of production in 1907, in estimating half a ton lost for every ton mined, this supply would last 2,550 years.

Kansas.—The areas in Kansas known to contain workable coal are placed at 3,100 square miles, although in addition to this there are 15,780 square miles which may contain workable coal. The estimated supply, when mining first began, is placed at 7,022,000,000 short tons. From this there has been produced from 1869 (the year of earliest production) to the close of 1907 a total of 91,176,204 short tons. This represents an exhaustion, including loss in mining, of about 136,000,000 short tons, from which it would appear that about 1.9 per cent of the original supply has been exhausted. The production in 1907 was 7,322,449 short tons, equivalent to an exhaustion of 10,000,000 short tons, which would indicate, at the rate of production in 1907, that the known coal supply of Kansas would last approximately 700 years.

Kentucky.—Kentucky is the only one of the coal-producing States which has within its borders areas belonging to two of the great coal fields. The eastern counties of the State are underlain by the coal beds of the great Appalachian system, while the southern limits of the central or eastern interior field are found in the more northern counties of the western part of the State. The eastern areas contain 10,270 square miles, the contents of which, when mining began, are estimated at 67,787,000,000 short tons. The western areas contain 6,400 square miles, the original contents of which are placed at 36,240,000,000 short tons. The total estimated original supply of the State was therefore 104,027,000,000 short tons. Mining began early in the second quarter of the nineteenth century, and it is estimated that from 1829 to 1835 the production ranged from 2,000 to 6,000 tons a year. The production in 1907 was 10,753,124 short tons, and the total production to the close of the year was 122,404,574 short tons, which represents an exhaustion of 184,000,000 short tons, or 0.18 of 1 per cent of the original supply. The quantity of coal left in the ground at the close of 1907 would then be 103,844,000,000 tons, of which approximately 67,000,000,000 short tons would be considered available, or, in other words, the supply at the close of 1907 was 6,700 times the production in that year.

Maryland.—The coal fields of Maryland are confined to a limited area in Allegany and Garrett counties in the western part of the State. This area has an extent of 455 square miles and the original supply is estimated to have been 8,044,000,000 short tons. Mining began early in the nineteenth century, and shipments were made down the Potomac River in 1830. The first shipments by railroad were made in 1842, in which year 1,708 tons were shipped over the newly built Baltimore and Ohio Railroad. In 1907 the production amounted to 5,532,628 short tons, and the total production to the close of that year aggregated 147,606,548 short tons, equivalent to an exhaustion, including waste, of 221,000,000 tons, or not quite 3 per cent of the original supply. The supply still remaining at the close of 1907 was 7,823,000,000 short tons, 1,422 times the production and 948 times the exhaustion represented by the production of that year.

Michigan.—The coal fields of Michigan are the only ones within the drainage basin of the Great Lakes. They occupy an area of approximately 11,000 square miles and are estimated to have contained when mining first began a total of 12,000,000,000 short tons of coal. Although coal mining has been carried on in Michigan for about seventy years, it is only a little more than a decade since it became of any importance as an industry, the production exceeding a million tons a year for the first time in 1901. The total production to the close of 1907 was 13,842,943 short tons, which, including waste, represents an exhaustion of 21,000,000 short tons, or 0.175 of 1 per cent of the total original supply. The production of Michigan in 1907 was 2,035,858 short tons. The supply remaining at the close of that year was, according to the best estimates, 11,979,000,000 short tons, of which 7,986,000,000 tons would be considered as available. This is equivalent to 3,900 times the production of 1907.

Missouri.—The original coal supply of Missouri is estimated to have been 40,000,000,000 short tons, included within an area of 23,000 square miles. The production of the State to the close of 1907 had amounted to 97,618,106 short tons, representing an exhaustion of approximately 146,000,000 tons, or 0.36 of 1 per cent of the original supply. The production in 1907 was 3,997,936 short tons, which is equivalent to an exhaustion of approximately 6,000,000 tons. The supply remaining at the close of 1907 is about 6,500 times the exhaustion created by the production in that year.

Montana.—Montana's scattered coal fields, known to contain workable coals, aggregate 34,067 square miles, while the areas which may contain workable coal, but which are not well known, amount to 17,575 square miles. The original contents of these coal fields are estimated to have been 303,060,000,000 short tons, from which there have been mined to the close of 1907 approximately 24,740,000 tons, representing an exhaustion of 37,000,000 tons, or 0.012 of 1 per cent of the original supply. The production in 1907 of a little over 2,000,000 tons is equivalent to an exhaustion of about 3,000,000 tons, and the coal left in the ground was 100,000 times that exhausted.

New Mexico.—The coal fields of New Mexico aggregate a total area of 18,335 square miles, and the original supply is estimated to have been 163,780,000,000 short tons, from which there had been produced to the close of 1907 a total of 22,325,432 short tons, representing an exhaustion of 33,000,000 tons, or 0.02 of 1 per cent of the original supply. The production in 1907 (2,628,959 short tons) is equal to nearly 12 per cent of the entire production of the coal to the close of that year, while the coal left in the ground is nearly 65,000 times the production in 1907, and over 40,000 times the exhaustion represented by that production.

North Carolina.—Two small areas of Triassic age contain all the coal known to exist in North Carolina. The total area is about 60 square miles, and the original contents of the field are estimated at 200,000,000 short tons. These areas have never been worked to any large extent, and the total production to the close of 1907 was less than half a million tons.

North Dakota.—Although the coal fields of North Dakota are of wide extent, the coal itself is all of lignitic character and of little commercial value at the present time. The total areas supposed to contain workable lignite are placed at 35,500 square miles and the original contents have been estimated at 500,000,000,000 short tons. The production, particularly considering the large supply, has been very small, the total exhaustion to the close of 1907 having amounted to only 4,000,000 tons.

Ohio.—Compared with the supply of coal originally contained within the coal fields of Ohio, the rate of exhaustion has been greater than that of any other State in the Appalachian system, with the exception of Maryland. The estimated original supply contained within an area of 12,660 square miles was 86,028,000,000 short tons. The first record we have of the production in the State is in the year 1838, when 119,952 short tons of coal were mined. Ohio's output was at that time exceeded only by the production of Pennsylvania anthracite and bituminous coal from the Richmond basin. From 1845 to 1875 Ohio ranked second among the coal-producing States. In 1876 it was surpassed by Illinois, and since 1896, when it was surpassed by West Virginia, it has ranked fourth among the coal-producing States. In 1907 Ohio contributed 32,142,419 short tons of coal to the total product of that year. The total output of Ohio mines from 1838 to the close of 1907, a period of seventy years, has amounted to 492,769,358 short tons, representing an exhaustion of 739,000,000 tons, or something less than 0.9 of 1 per cent of the estimated original supply. The production of 1907, which was a little less than 7 per cent of the production to the close of that year, was equivalent to an exhaustion of about 48,000,000 tons. Deducting from the original supply the exhaustion at the close of 1907, there would still be available on January 1, 1908, 85,980,000,000 tons, or nearly 2,000 times the production in 1907.

Oklahoma.—All of the coal in Oklahoma is contained in that portion of the State which was formerly known as the Creek, Cherokee, and Choctaw nations of Indian Territory. The total area underlain by workable coal is estimated to be about 10,000 square miles, and the original contents are estimated to have been 79,278,000,000 tons. Mining did not begin in Indian Territory until comparatively late, the first production reported having been in 1880, when 120,947 short tons were produced. The industry has progressed rapidly, however, and the production in 1907 amounted to 3,642,658 short tons. The total production to the close of 1907 was 39,845,015 short tons, representing an exhaustion of approximately 60,000,000 tons. The quantity of coal left in the ground in Oklahoma at the close of 1907 was 13,000 times the exhaustion represented by the production in that year.

Oregon.—As far as known the earliest record of coal production in Oregon was in 1880, when the output amounted to 43,205 short tons. In 1907 Oregon's production was 70,981 short tons, and the aggregate production from 1880 to the close of 1907 was 1,790,392 tons, which represents an exhaustion of 2,700,000 tons. The total area in the State containing workable coals is estimated at 230 square miles and the original supply at 1,000,000,000 short tons.

Pennsylvania.—The supplies of anthracite coal in Pennsylvania are discussed in another portion of this paper. The bituminous areas in the western portion of the State are estimated to have an extent of 14,200 square miles and to have contained, when mining first began, 112,574,000,000 short tons. The development of the Pennsylvania bituminous coal fields did not begin until about twenty years after anthracite mining was established as an industry, the first production having been reported in the census year 1840, when 464,826 short tons were mined. Up to 1897 the production of anthracite coal in Pennsylvania exceeded that of bituminous, but in 1898 the bituminous production took the lead and has continued to lead since that date. In 1907 the production of bituminous coal exceeded that of anthracite by nearly 80 per cent, and as indicative of the extent to which the bituminous coal-mining industry of Pennsylvania has grown it may be stated that the production in 1907 was nearly three times that of 1897, only ten years before. The total production of bituminous coal in Pennsylvania to the close of 1907 was 1,846,069,253 short tons, which was equivalent to an exhaustion of 2,760,000,000 tons, or 2.5 per cent of the original supply. The exhaustion represented by the production in 1907 was 225,000,000 tons. The supply remaining at the close of 1907 was 109,804,000,000 tons, or 492 times the exhaustion represented by the production of that year.

South Dakota.—The northwest corner of South Dakota contains the southern extension of the North Dakota lignite beds, and it is estimated that about 6,000 square miles of this territory may contain workable lignites. The contents are estimated at 10,000,000,000 short tons, and these are practically untouched.

Tennessee.—The coal fields of Tennessee are contained in a narrow strip in the eastern counties of the State, where the Appalachian province crosses the State in a northeast-southwest direction. Mining began sometime between 1830 and 1840, and the census for the latter year reported a production of 558 tons. Coal mining did not, however, develop into an important industry in Tennessee until after the close of the civil war, and it was not until 1883 that the production reached as much as 1,000,000 tons annually. Since that time it has increased with notable regularity, until in 1907 the production amounted to 6,810,243 short tons. The total area of bituminous coal in the State is estimated at 4,400 square miles, and the total original supply at 25,665,000,000 tons. The total production to the close of 1907 amounted to 84,304,601 short tons, representing an exhaustion of approximately 126,000,000 tons, or about 0.5 of 1 per cent of the original supply. The exhaustion represented by the production in 1907 was approximately 10,200,000 tons, and the supply left in the ground at the close of the year was equal to 2,500 times this exhaustion.

Texas.—The known bituminous coal fields of Texas are estimated to contain 8,200 square miles, and the exploited lignite fields 2,000 square miles. In addition to this there are 5,300 square miles which may contain workable bituminous coal and 53,000 square miles which may contain workable lignite. The estimated contents of the bituminous coal fields when mining first began in Texas were 8,000,000,000 short tons, and of the lignite fields 23,000,000,000 short tons. The exploitation of both the lignite and the bituminous areas is of comparatively recent date, no production having been reported from Texas prior to 1884, and it was not until 1901 that the output reached as much as 1,000,000 tons. The production to the close of 1907 was 14,444,948 short tons, representing an exhaustion of 22,000,000 tons, or 0.07 of 1 per cent of the original supply.

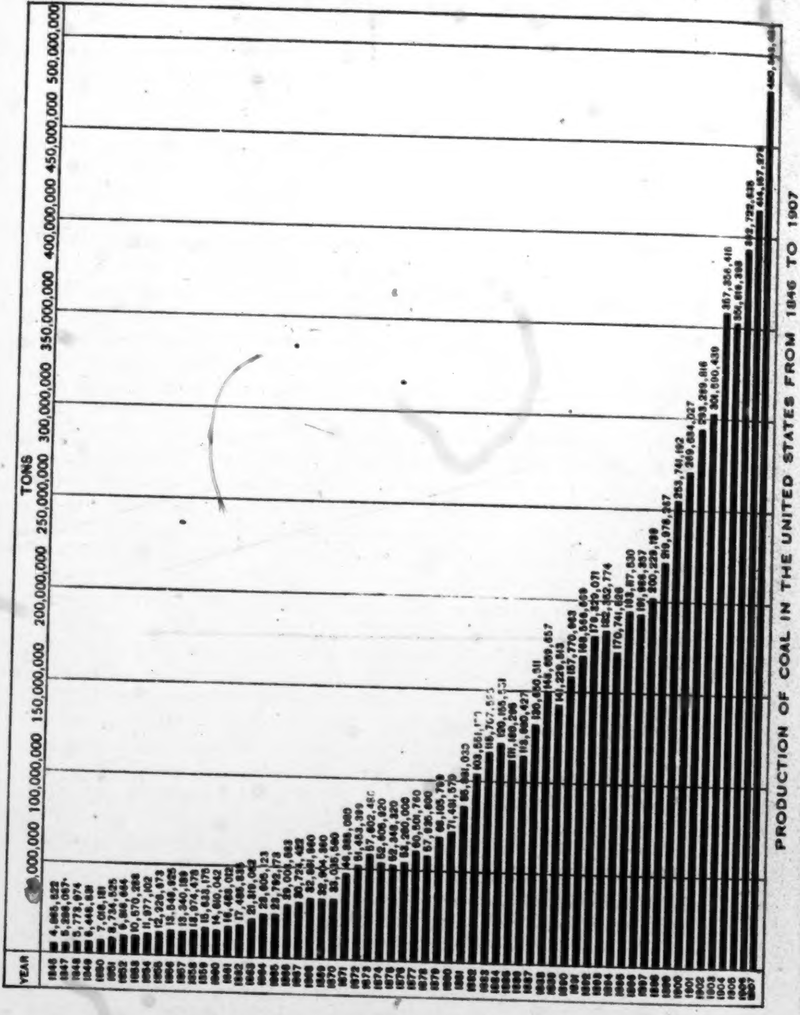
Utah.—Utah's coal fields are contained in scattered areas aggregating 15,130 square miles. The quality of the coals ranges from subbituminous to anthracite. The estimated original supply was 196,458,000,000 short tons, from which the exhaustion, including waste, at the close of 1907, was 28,000,000 short tons, indicating that there were still remaining in the ground 196,430,000,000 tons, or a little more than 100,000 times the production of 1907.

Virginia.—The Richmond basin in Virginia, where coal mining in the United States was first carried on, contains 150 square miles. Another small area in Montgomery County contains 200 square miles of coal-productive territory, but the principal regions are in the southwestern corner of the State, which is crossed by the Appalachian system. The portion of the Appalachian coal field in Virginia is estimated to be 1,550 square miles. The original supply has been placed at 22,500,000,000 short tons. From this there had been produced at the close of 1907 a total of 57,229,152 short tons, representing an exhaustion of 86,000,000 tons. The production in 1907 was 4,710,895 short tons, equivalent to an exhaustion of a little over 7,000,000 tons, so that the coal left in the ground in Virginia at the close of 1907 was 2,000 times the exhaustion represented by the production of that year.

Washington.—Washington's coal supply is contained within a number of areas that are scattered over the State and aggregate approximately 1,100 square miles. The estimated original supply was 20,000,000,000 short tons, and while mining began there as early as 1860, the total production to the close of 1907 was only 43,108,697 short tons, of which nearly 50 per cent was produced within the last seven years. The exhaustion represented by the production to the close of 1907 was 64,000,000 short tons, which is equivalent to about one-third of 1 per cent of the original supply. The quantity of coal still in the ground at the close of 1907 was estimated to be 19,936,000,000 short tons, equivalent to 5,400 times the production of 1907 and 3,600 times the exhaustion made by that output.

West Virginia.—The total area containing workable coal in Virginia is 17,000 square miles, and the original supply when mining first began was 231,039,000,000 tons. West Virginia was not admitted as a State until 1863, in which year the production amounted to 444,648 short tons. The quantity of coal mined prior to that time, in the portion of Virginia which afterwards became West Virginia, was not sufficient to materially affect the total output. For a number of years West Virginia has been third among the coal-producing States, and in 1907 the production amounted to a little over 48,000,000 tons. The aggregate production to the close of 1907 was 434,198,539 short tons, equivalent to an exhaustion of 650,000,000 tons. At the beginning of 1908 there still remained available in the coal fields of West Virginia 230,389,000,000 short tons, nearly 4,800 times the production in 1907, or 3,200 times the exhaustion represented by the 1907 output.

Wyoming.—The estimated original coal supply of Wyoming is larger than that credited to any other coal-producing State, with the exception of North Dakota. In the latter State, however, the entire supply is lignite, while in Wyoming the coals are of subbituminous or of bituminous character. The total area which may contain workable coals has been estimated at 50,793 square miles, and the contents of this field, when mining first began, at 424,085,000,000 short tons. In comparison the aggregate production at the close of 1907, which was 77,818,765 short tons, appears insignificant. The total exhaustion of the beds to the close of 1907 amounted to 116,000,000 short tons, or 0.027 of 1 per cent of the total estimated supply.



PRODUCTION OF COAL IN THE UNITED STATES FROM 1846 TO 1907

ESTIMATES OF FUTURE COAL PRODUCTION.

By Henry Gannett,
United States Geological Survey.

The Geological Survey estimates the amount of coal remaining in the ground to be 3,147,043,000,000 tons, of which about two-thirds is easily obtainable, the other third being of indifferent or poor quality and difficult of mining.

In nearly a century of mining about one-third of 1 per cent of the supply has been taken out of the ground. The production during the year 1907, which was more than 480,000,000 tons, was much larger than in any previous year.

The Geological Survey also estimates that in mining practice about 1 ton of coal is lost for every 2 tons won, either by leaving it in the ground or in breaking and transporting.

In order to reach even an approximate idea of the length of time that this coal supply will last, it is necessary in the first place to estimate the probable annual production in the future. That it will increase beyond the present maximum goes without saying, but at what rates and for how long a period will the increase continue are questions whose solution can only be guessed. Unfortunately we have very few data upon which to build. The rate of yearly increase of production is very irregular, so irregular that no conclusions can be drawn from it. It is impossible to construct from it a smooth curve which might be projected into the future. Even if ten-year averages be taken, and the rate of progress be thus obtained per decade, the result is very unsatisfactory, for the reason that one of the decades may consist mainly of a period of prosperity while the preceding and succeeding decades may contain periods of business depression. It is necessary, therefore, in order to obtain rates of increase which are fairly comparable with one another that we take the rate of production for periods sufficiently long to include a period of prosperity with one of business depression, i. e., twenty years. This has been done with the following results, expressed in terms of millions of tons, each the production of twenty years, with percentages of increase:

Production of coal and rate of increase, by twenty-year periods, 1828 to 1907.

Years.	Production.	Per cent of increase.
	Millions of tons.	
1828-1847	37.3	....
1848-1867	306.0	720
1868-1887	1,451.0	374
1888-1907	5,068.0	249

We have here three rates of increase and they show a very rapid decrease. It would, of course, be folly to assume that the latest rate of increase, 249 per cent, is to continue indefinitely or even at all. There is every indication that the next twenty years will show a great diminution; indeed, at the present rate of increase of production, all the coal would be exhausted before the end of the present century.

The normal curve formed by rates of increase is a hyperbola—that is, if population or production, etc., is not interfered with by extraneous influences, it tends to increase in a constantly diminishing ratio, but never ceases to increase, and the successive rates of increase when plotted to scale form a hyperbolic curve. The equation of this curve, referred to its asymptotes, is $(x-a)\ (y-b)=c$. We have three points on this curve, i. e.:

$$\begin{array}{ll} x=1 & y=720 \\ x=2 & y=374 \\ x=3 & y=249 \end{array}$$

x being periods of time, in this case twenty-year intervals, and y being the corresponding per cents of increase.

Using these values in the above equation, we obtain for the constants:

$$\begin{aligned} a&=13 \\ b&=17 \\ c&=833 \end{aligned}$$

Substituting these values of the constants in the equation, and giving x successively values of 4, 5, 6, etc., the following values for y, the per cents of increase, are obtained, as shown below, with the resulting amount of coal production in each successive twenty-year period:

Estimated production of coal and rate of increase, by twenty-year periods, 1908–2067.

Years.	Per cent of increase.	Production.
1908-1927		*Millions of tons.*
1928-1947	185	21,375
1948-1967	145	52,369
1968-1987	119	114,688
1988-2007	100	229,376
2008-2027	85	424,346
2028-2047	74	738,360
2048-2067	65	1,218,297
	58	1,924,909

The production for the double decade 2048–2067 is estimated at the enormous rate of 274 tons (including waste) for every man, woman, and child in the country, or, excluding waste, 183 tons per capita.

As is seen above, the easily accessible coal may be exhausted about the year 2040, and all coal about the middle of that century; i. e., ten years later.

It must not be supposed, however, that this programme will be carried out. In the first place, the data upon which this curve has been constructed are very few, and the curve is correspondingly weak. They are, however, all that we possess and the foregoing is probably the best way to use them.

In the future, powerful extraneous influences will come to bear on coal production, and all, as far as can be foreseen, except possible exports, are in favor of lengthening the life of the supply.

As soon as the end appears in sight the price will rise and production diminish, and that progressively. This interference with the law of decreasing increase, produced by growing scarcity, will of course prolong the life of our coal reserves, but at the same time will greatly hamper our industries dependent on this fuel.

Again, the development of water power will prove another disturbing factor which will prolong the life of our coal supply. To a great extent, city heating and lighting and power for manufacturing, and transportation will in the near future be furnished by water power. It is estimated that in round numbers 30,000,000 horsepower are going to waste in our streams to-day, most of which can and will be utilized, replacing coal. If all the latent water power in the country were harnessed within the next twenty years, it would probably prolong the life of the coal supply by about eighty years.

Furthermore, the economies to be introduced in mining and handling coal will result in saving a large part of the present waste. If the production and transportation were relieved of all waste within the next twenty years, the coal supply would last twenty years longer.

THE PETROLEUM RESOURCES OF THE UNITED STATES.

By David T. Day,
United States Geological Survey.

EXTENT OF THE PETROLEUM FIELDS.

This report deals with the petroleum fields of the United States as known at present; that is, it is limited to the petroleum pools actually developed, or what is known as "proved territory."

LOCATION.

The areas where petroleum is known to occur at present are shown on the accompanying map of the United States.

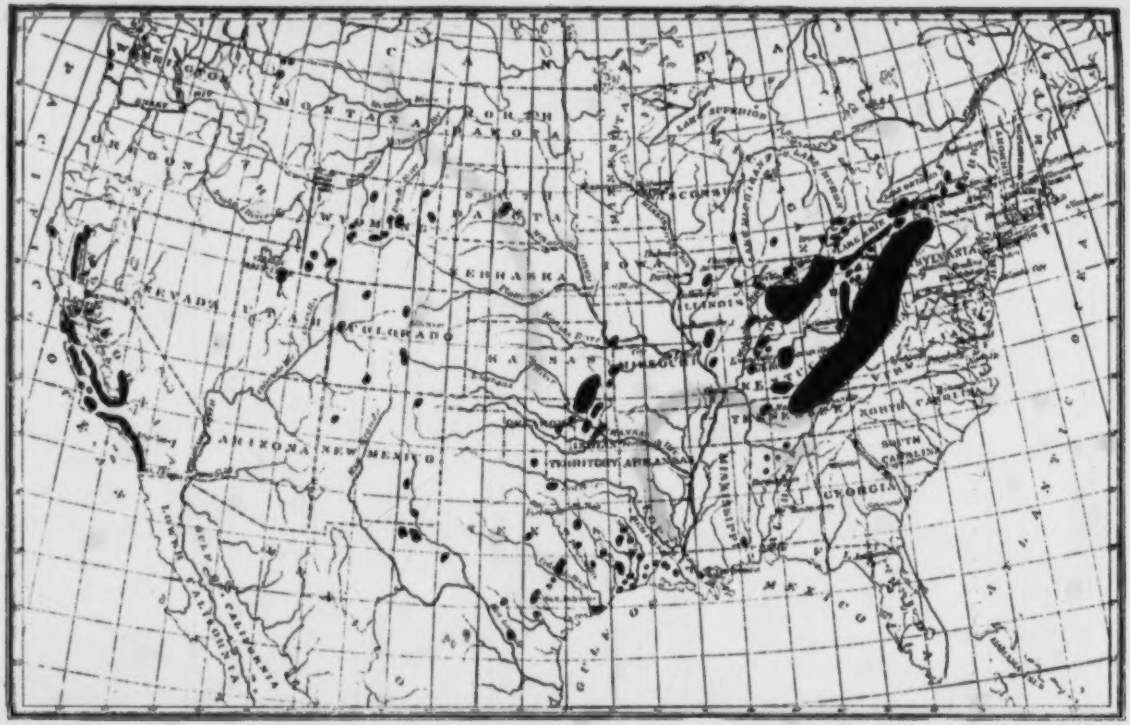
Appalachian.—Petroleum is unknown and improbable east of the Allegheny Mountains. Parallel with their western flank the Appalachian belt extends from western New York to Tennessee. It crosses western Pennsylvania, and there petroleum was first found in large quantity. The supply in Pennsylvania is rapidly becoming exhausted. It has declined to one-third of its highest rate of production. This high-production mark was only seventeen years ago. The Appalachian field continues across West Virginia and includes the eastern edge of Ohio. Farther south moderate supplies have long been known, and they are still being developed in Kentucky and Tennessee.

"Petroleum" in this report means crude petroleum, as it comes from the earth; that is, before it has been refined. The word "oil" refers to products obtained from petroleum.

The petroleum of this field (known generally as Pennsylvania petroleum) differs essentially from that of the other fields in the United States. It is notably different from any other petroleum thus far found in the world. It is most easily converted into lamp oil, and yields the greatest percentage of this product. The lamp oil is the finest yet produced—in fact, much better than any other except the products from western Ohio and Indiana, and the petroleum from this latter field costs more to refine.

Farther south, in Kentucky and Tennessee, the product is progressively poorer, but is much better than Russian or any other of the foreign products with which it comes in competition.

Lima-Indiana.—The second great field in historical development covers a considerable portion of northwestern Ohio and eastern Indiana, and small isolated pools of petroleum of the same general character are found elsewhere in Indiana. This petroleum is more



C A N A D A
WASHINGTON
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
MINNESOTA
WISCONSIN
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
OREGON
IDAHO
WYOMING
NEBRASKA
IOWA
ILLINOIS
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
KENTUCKY
PENNSYLVANIA
VIRGINIA
NORTH CAROLINA
SOUTH CAROLINA
TENNESSEE
ARIZONA
NEW MEXICO
INDIAN TERRITORY
ARKANSAS
MISSISSIPPI
GEORGIA
TEXAS
LOWER CALIFORNIA
GULF OF CALIFORNIA
GULF OF MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN

PETROLEUM AND NATURAL GAS FIELDS.

orm than the Pennsylvania varieties. It contains, quite ormly, less gasoline and less lamp oils, and the presence of nic sulphur compounds results in an average of one-half of 1 cent of sulphur, which can be removed only by ingenious and paratively costly refining processes.

linois.—In Illinois, near the eastern edge, a strip of territory e 30 miles long and of irregular width, averaging about 6 miles, ielding a comparatively enormous quantity of petroleum. It is r from sulphur than the Lima-Indiana variety, and occasionally ains sufficient asphalt to ally it to the petroleum from the next to the west, the Mid-Continent field.

id-Continent.—This comprises the pools in Kansas and Okla- a, and must eventually include, for statistical purposes, the ls in northwestern Louisiana and northern Texas. The yield n this field within the last two years has been so large as to greatly urb the industry, on account of the difficulty of providing suffi- t refining and transportation facilities. This petroleum differs n Pennsylvania petroleum in frequently containing small amounts asphalt, and also in containing hydrocarbons less stable in their on toward the chemicals used in refining them. Nevertheless, it proved possible to obtain good yields of perfectly satisfactory ducts covering the entire range from gasoline to paraffin wax. ne of the petroleum of this field contains sufficient water and er foreign materials to complicate the matter of giving it a just uation, and also to add to the difficulty of the refining processes.

n the Mid-Continent field the Glenn pool, located a few miles th of Tulsa, Okla., is a good illustration of the uncertainties of roleum production. A well drilled in 1905 happened to be ated a few feet within the limits of this pool. Had it been located ghtly farther to the east the field would not then have been dis- vered, but the very considerable flow from this well caused more n usual excitement, and nearly all of the wells drilled to the west oved good producers. The wells produced 1,000,000 barrels from 00 acres of ground within the year 1906. Well drilling was rapid, in fact, that the pool reached its maximum production rteen months after the discovery of the first well, and from t time the production declined almost as rapidly as it had in- eased, until the decline was arrested by cleaning out the wells, and terward, also, shooting them with nitroglycerine. The transpor- tion companies could not keep up with such rapid development, d perhaps 1,000,000 barrels of petroleum was wasted on the ound within two years.

Gulf.—For many years the escape of petroleum and natural gas the surface has been noted at many points in Texas and in south- n Louisiana. This led to the drilling, in 1901, of a well at Spindle op, near Beaumont, Tex., from which probably more than 500,000 rrels of petroleum flowed before the well could be checked. The ld was soon extended to Jennings and Welsh, and eventually to nse la Butte, in Louisiana. Other wells were rapidly drilled, re- lting in a large addition to the petroleum product of the United tates. This petroleum contains a large percentage of asphaltum nd relatively small amounts of gasoline and lamp oils, and therefore ffers little temptation to the refiner. It is also handicapped by the resence of sulphur in many forms. For some years it was disposed of principally to the railroads and burned as fuel on locomotives, and thus caused considerable industrial development in Texas, because it was necessary to sell the petroleum at prices as low as 10 cents per barrel in order to find a market for the product. After persistent endeavor it has become possible to refine this petroleum successfully, and some of the products have peculiar value. The lubricating oils find considerable favor and the gasoline has special value as a solvent.

California.—Petroleum, principally asphaltic and similar to the Texas petroleum, except that it is sometimes free from sulphur, is found in many areas in California, between Los Angeles and San Francisco, the principal fields being Los Angeles City, Puente Hills, Kern River, Sunset, McKittrick, Santa Maria, Coalinga, and Fullerton. The lack of an adequate supply of fuel in California has led to very great development of the petroleum industry for this purpose, as shown in the production tables below, and investigations have shown that the quantity of petroleum existing in California is greater than in any other known field in the United States.

Smaller fields.—The great fields described above are those which control the industry. West of the Mid-Continent field and east of the California field are several smaller ones (as thus far developed) in Colorado and Wyoming, with promises of fields in New Mexico, Utah, Idaho, Montana, Oregon, and Washington. In Alaska at least two petroleum pools have been discovered which may possibly be capable of considerable output when the market conditions become favorable.

There are many regions in the United States where there is no geological improbabality of finding petroleum. Such geological improbability exists where the rocks are greatly disturbed and broken up to such a depth as to prevent probable drilling to the undisturbed sedimentary rocks which could furnish good storage for petroleum.

AREAS.

In each petroleum field it has become necessary for the pipe-line companies and for the producers themselves to locate on detailed maps every well as it is drilled, distinguishing the productive from dry wells, in order that the limitations of each field may be promptly determined. From these maps, principally, with the aid of many independent data collected by himself, Dr. F. H. Oliphant has compiled a map of the petroleum fields in the United States, which is appended to this report. From measurements of the areas on this map, together with revisions from the map recently published by Dr. I. C. White, state geologist of West Virginia, and with the aid of Dr. H. Foster Bain, director of the Geological Survey of Illinois; Ralph Arnold, in charge of the petroleum investigations in California for the United States Geological Survey; A. C. Veatch, for Wyoming; Dr. J. A. Bownocker, state geologist of Ohio; and with additional data from Doctor Oliphant, the following table has been compiled, giving in square miles the area of petroleum territory in each State. The figures here given are merely general approximations, which lack very much in uniformity. In some States the area shows simply actual "proved territory." In others, as in Alabama, it indicates the region in which the future production of petroleum is probable. In many others considerable territory is included between individual pools which in all probability will prove to be barren, and while the extensions of "proved territory" will, to a certain extent, offset that which proves eventually to be barren, the table is, at best, a rough approximation. It takes no account whatever of the fact that other fields now altogether unknown will be developed in the future.

State.	Square miles.	State.	Square miles.	State.	Square miles.
Alaska	100	Louisiana	60	Pennsylvania	2,000
Alabama	50	Michigan	80	Tennessee	80
California	850	Missouri	30	Texas	400
Colorado	200	New Mexico	80	Utah	40
Idaho	10	New York	300	West Virginia	570
Illinois	200	Ohio:		Wyoming	750
Indiana	1,000	Eastern	115		
Kansas	200	Western	535	Total	8,450
Kentucky	400	Oklahoma	400		

THICKNESS.

The thickness of the "pay sands" in these fields varies within wide limits. In West Virginia Doctor White considers 5 feet of "pay sand" to be a safe estimate in good producing territory. This is sufficiently liberal for Pennsylvania also. In other fields much thicker "pay sands" are recognized. In Illinois the "pay" streaks in the petroleum sands vary from 2 feet to over 30 feet in thickness, and at Spindle Top, in Texas, an average thickness of over 75 feet has been calculated. In California, particularly in the Kern River field, the "pay sands" reach a thickness of over 100 feet.

POROSITY.

The rocks composing the "pay" streaks in the petroleum-bearing formations of the United States vary from sandstones and dolomites, with the compactness of ordinary building stone, to unconsolidated sands and coarse gravel, and, in exceptional cases, honeycombed limestones, in which actual cavities of considerable size have to be reckoned with. It has been customary to consider 10 per cent as near the average porosity of the "pay sands," with a latitude of variation from practically nothing in damp shales to over 30 per cent in the most porous strata.

The principal effect of these variations in porosity is rather upon the rate at which the petroleum can be obtained from the pool than upon the total amount obtainable.

PROBABLE SUPPLY OF PETROLEUM.

CAPACITY OF SANDS.

Assuming 10 per cent as the average porosity of "pay sands," 1 cubic foot of "pay sand" would yield approximately 1 gallon of petroleum, or 5,000 barrels per acre of "pay sands" with an average thickness of 5 feet.

ESTIMATES OF YIELD.

The thickness most frequently reported for the "pay sands" of various fields is normally much in excess of 5 feet. In Pennsylvania, the reported thickness of petroleum-bearing strata will average more than this, and frequently more than one stratum has been noted in the same well, and yet, as will be shown in the tables of production below, the average yield per acre in Pennsylvania has been less than 800 barrels, and at the present rate of decline it is not probable that more than 800 barrels per acre will be obtained on the average in New York and Pennsylvania. It is fair to assume that 1,000 barrels per acre is a sufficient allowance for New York, Pennsylvania, West Virginia, Kentucky, Tennessee, Ohio, and Indiana. In Illinois, where the yields have been unusually great on account of "pay" streaks approximating 25 feet on the average, Doctor Bain estimates 8,000 barrels per acre as the result of conferences with the producers. This is taking into consideration the fact that in the northern portions of the field the yield is frequently not greater than 2,500 barrels per acre. In the Texas field the supply is better calculated by consideration of the amount already yielded and the rate of decline, from which it is estimated that the Texas fields will surely yield 200,000,000 barrels, and Louisiana 50,000,000 barrels. In Oklahoma the remaining productive capacity is estimated by Mr. W. J. Reed, of the United States Geological Survey, at a minimum of 282,875,000 barrels. In the remaining fields, outside of California, 1,000 barrels per acre is believed to be a sufficient allowance for the known fields.

In California very careful measurements by Mr. Arnold have resulted in an estimate of 8,500,000,000 barrels of petroleum stored in the rocks of that State, of which perhaps 5,000,000,000 barrels may be expected to be produced. Recognizing that the amount of oil obtainable from these known fields is a matter largely of conjecture, it can only be based as above, upon what the fields have already yielded, and upon the thickness and relative porosity of the sands, but estimates of different authorities must vary between wide limits, and this should be borne in mind in considering the following table.

Estimated minimum and maximum total yield of the petroleum fields of the United States.

	Minimum.	Maximum.
Appalachian field	2,000,000,000	5,000,000,000
Lima-Indiana field	1,000,000,000	3,000,000,000
Illinois field	350,000,000	1,000,000,000
Mid-Continent field	400,000,000	1,000,000,000
Gulf field	250,000,000	1,000,000,000
California field	5,000,000,000	8,500,000,000
Minor fields	1,000,000,000	5,000,000,000
Total	10,000,000,000	24,500,000,000

PRODUCTION OF PETROLEUM.

BEGINNING OF THE INDUSTRY.

Production of petroleum in the United States has been considered statistically only since 1859. The production to that date incidental to the salt industry, and the occasional use of petroleum from springs for medicinal purposes, had no bearing on the industry which was to follow, except in one way. Samuel Kier, of Pittsburg, had salt wells at Tarentum, from which he accumulated so much petroleum (more than 50 barrels) that he applied himself to the problem of developing a definite trade for it, and succeeded by means of introducing a lamp with a chimney. He also partly refined this petroleum. A. C. Ferris, also of Pittsburg, applying himself in the same direction, began the distribution of this oil to other cities, and the efforts of these two merchants created and maintained a demand which caused Colonel Drake to drill a well for petroleum at Titusville in 1859. In the course of the half century since the drilling of the Drake well 1,806,608,463 barrels of petroleum, or 240,919,676 tons, have been produced, worth $1,654,877,685. Details of this production are shown in the following table:

Production of crude petroleum in the United States, 1859–1907, by years and by States, in barrels of 42 gallons.

Year.	Pennsylvania and New York.	Ohio.	West Virginia.	California.	Kentucky and Tennessee.	Colorado.	Indiana.	Illinois.
1859	2,000	....	....	....	....	....	....	....
1860	500,000	....	....	....	....	....	....	....
1861	2,113,609	....	....	....	....	....	....	....
1862	3,056,690	....	....	....	....	....	....	....
1863	2,611,309	....	....	....	....	....	....	....
1864	2,116,109	....	....	....	....	....	....	....
1865	2,497,700	....	....	....	....	....	....	....
1866	3,597,700	....	....	....	....	....	....	....
1867	3,347,300	....	....	....	....	....	....	....
1868	3,646,117	....	....	....	....	....	....	....
1869	4,215,000	....	....	....	....	....	....	....
1870	5,260,745	....	....	....	....	....	....	....
1871	5,205,234	....	....	....	....	....	....	....
1872	6,293,194	....	....	....	....	....	....	....
1873	9,893,786	....	....	....	....	....	....	....
1874	10,926,945	....	....	....	....	....	....	....
1875	8,787,514	....	....	....	....	....	....	....
1876	8,968,906	31,763	120,000	12,000	....	....	....	....
1877	13,135,475	29,888	172,000	13,000	....	....	....	....
1878	15,163,462	38,179	180,000	15,227	....	....	....	....
1879	19,685,176	29,112	180,000	19,858	....	....	....	....
1880	26,027,631	38,940	179,000	40,552	....	....	....	....
1881	27,376,509	33,867	151,000	99,862	....	....	....	....
1882	30,053,500	39,761	128,000	128,636	....	....	....	....
1883	23,128,389	47,632	126,000	142,857	4,755	....	....	....
1884	23,772,209	90,081	90,000	262,000	4,148	....	....	....
1885	20,776,041	661,580	91,000	325,000	5,164	....	....	....
1886	25,798,000	1,782,970	102,000	377,145	4,726	....	....	....
1887	22,356,193	5,022,632	145,000	678,572	4,791	76,295	....	....
1888	16,488,668	10,010,868	119,448	690,333	5,096	297,612	....	....
1889	21,487,435	12,471,466	544,113	303,220	5,400	316,476	33,375	1,460
1890	28,458,208	16,124,656	492,578	307,360	6,000	368,842	63,496	900
1891	33,009,236	17,740,301	2,406,218	323,600	9,000	665,482	136,634	675
1892	28,422,377	16,362,921	3,810,086	385,049	6,500	824,000	698,068	521
1893	20,314,513	16,249,769	8,445,412	470,179	3,000	594,390	2,335,293	400
1894	19,019,990	16,792,154	8,577,624	705,969	1,500	515,746	3,688,666	300
1895	19,144,390	19,545,233	8,120,125	1,208,482	1,500	438,232	4,386,132	200
1896	20,584,421	23,941,169	10,019,770	1,252,777	1,680	361,450	4,680,732	250
1897	19,262,066	21,560,515	13,090,045	1,903,411	322	384,934	4,122,356	500
1898	15,948,464	18,738,708	13,615,101	2,257,207	5,568	444,383	3,730,907	360
1899	14,374,512	21,142,108	13,910,630	2,642,095	18,280	390,278	3,848,182	360
1900	14,559,127	22,362,730	16,195,675	4,324,484	62,259	317,385	4,874,392	200
1901	13,831,996	21,648,083	14,177,126	8,786,330	137,259	460,520	5,757,086	250
1902	13,183,610	21,014,231	13,513,345	13,984,268	185,331	396,901	7,480,896	200
1903	12,518,134	20,480,286	12,899,395	24,382,472	554,286	483,925	9,186,411	....
1904	12,239,026	18,876,631	12,644,686	29,649,434	998,284	501,763	11,339,124	....
1905	11,554,777	16,346,660	11,578,110	33,427,473	1,217,337	376,238	10,964,247	181,084
1906	11,500,410	14,787,763	10,120,935	33,098,598	1,213,548	327,582	7,673,477	4,397,050
1907	11,211,606	12,207,448	9,095,296	39,748,375	820,844	331,851	5,128,037	24,281,973
Total	687,425,409	366,250,105	185,039,718	201,965,825	5,276,578	8,874,285	90,127,511	28,866,683

Production of crude petroleum in the United States, 1859–1907, by years and by States, in barrels of 42 gallons—Continued.

Year.	Kansas.	Texas.	Missouri.	Oklahoma.	Wyoming.	Louisiana.	United States.	Total value.
1859	....	....	....	....	....	....	2,000	$32,000
1860	....	....	....	....	....	....	500,000	4,800,000
1861	....	....	....	....	....	....	2,113,609	1,035,668
1862	....	....	....	....	....	....	3,056,690	3,209,525
1863	....	....	....	....	....	....	2,611,309	8,225,663
1864	....	....	....	....	....	....	2,116,109	20,896,576
1865	....	....	....	....	....	....	2,497,700	16,459,853
1866	....	....	....	....	....	....	3,597,700	13,455,398
1867	....	....	....	....	....	....	3,347,300	8,066,993
1868	....	....	....	....	....	....	3,646,117	13,217,174
1869	....	....	....	....	....	....	4,215,000	23,730,450
1870	....	....	....	....	....	....	5,260,745	20,503,754
1871	....	....	....	....	....	....	5,205,234	22,591,180
1872	....	....	....	....	....	....	6,293,194	21,440,503
1873	....	....	....	....	....	....	9,893,786	18,100,464
1874	....	....	....	....	....	....	10,926,945	12,647,527
1875	....	....	....	....	....	....	8,787,514	7,368,133
1876	....	....	....	....	....	....	9,132,669	22,982,822
1877	....	....	....	....	....	....	13,350,363	31,788,566
1878	....	....	....	....	....	....	15,396,868	18,044,520
1879	....	....	....	....	....	....	19,914,146	17,210,708
1880	....	....	....	....	....	....	26,286,123	24,600,638
1881	....	....	....	....	....	....	27,661,238	23,512,051
1882	....	....	....	....	....	....	30,349,897	23,631,165
1883	....	....	....	....	....	....	23,449,633	25,740,252
1884	....	....	....	....	....	....	24,218,438	20,476,924
1885	....	....	....	....	....	....	21,858,785	19,193,694
1886	....	....	....	....	....	....	28,064,841	20,028,457
1887	....	....	....	....	....	....	28,283,483	18,856,606
1888	....	....	....	....	....	....	27,612,025	17,950,353
1889	500	48	20	....	....	....	35,163,513	26,963,340
1890	1,200	54	278	....	....	....	45,823,572	35,365,105
1891	1,400	54	25	30	....	....	54,292,655	30,526,553
1892	5,000	45	10	80	....	....	50,514,657	25,906,463
1893	18,000	50	50	10	....	....	48,431,066	28,932,326
1894	40,000	60	8	130	2,369	....	49,344,516	35,522,095
1895	44,430	50	10	37	3,455	....	52,892,276	57,691,279
1896	113,571	1,450	43	170	2,878	....	60,960,361	58,518,709
1897	81,098	65,975	19	625	3,650	....	60,475,516	40,929,611
1898	71,980	546,070	10	....	5,475	....	55,364,233	44,193,359
1899	69,700	669,013	132	....	5,560	....	57,070,850	64,603,904
1900	74,714	836,039	[a]1,602	6,472	5,450	....	63,620,529	75,752,691
1901	179,151	4,393,658	[b]2,335	10,000	5,400	....	69,389,194	66,417,335
1902	331,749	18,083,658	[a]757	37,100	6,253	548,617	88,766,916	71,178,910
1903	932,214	17,955,572	[a]3,000	138,911	8,960	917,771	100,461,337	94,694,050
1904	4,250,779	22,241,413	[a]2,572	1,366,748	11,542	2,958,958	117,080,960	101,175,455
1905	[c]12,013,495	28,136,189	[a]3,100	([d])	8,454	8,910,416	134,717,580	84,157,399
1906	[c]21,718,648	12,567,897	[a]3,500	([d])	[e]7,000	9,077,528	126,493,936	92,444,735
1907	[c]45,933,649	12,322,696	[a]4,000	([d])	9,339	5,000,221	166,095,335	120,106,749
Total	85,881,278	117,819,991	21,471	1,560,318	85,785	27,413,511	1,806,608,463	1,654,877,685

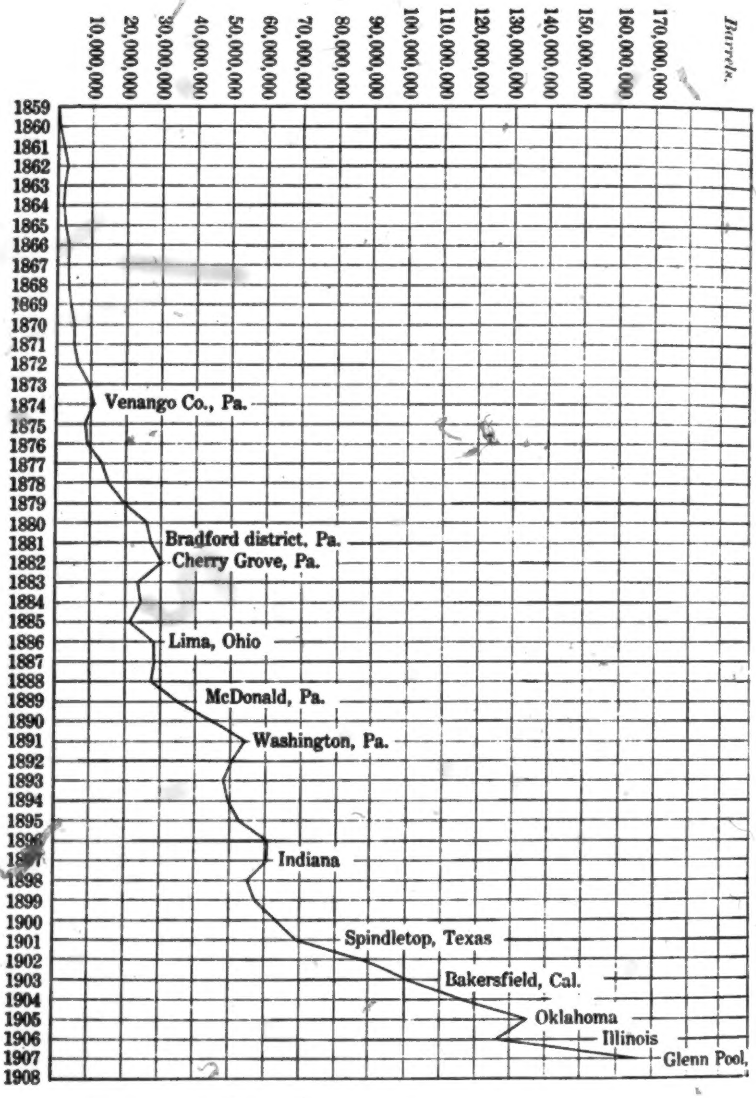
[a] Includes the production of Michigan.

[b] Includes production of Michigan and small production in Oklahoma.

[c] Includes production of Oklahoma.

[d] Included with Kansas.

[e] Estimated.



ANNUAL PRODUCTION OF PETROLEUM 1859 TO 1907.

New petroleum fields have been found and developed so rapidly as to more than offset the decrease of production in the older fields. Therefore, the rate of total production has shown a rapid increase from 500,000 barrels in 1860 to over 166,000,000 barrels in 1907. The rate of production is illustrated by the accompanying curve, on which are noted the sudden impulses resulting from the discovery of new fields. Grouped by the principal fields, the production of petroleum in the United States has been as follows:

Production of petroleum fields in each year from 1859 to 1907.

[Barrels of 42 gallons.]

Year.	Appalachian.	California.	Lima-Indiana.	Colorado-Wyoming.	Mid-Continent.	Gulf.	Illinois.	Total.
1859	2,000							2,000
1860	500,000							500,000
1861	2,113,609							2,113,609
1862	3,056,690							3,056,690
1863	2,611,309							2,611,309
1864	2,116,109							2,116,109
1865	2,497,700							2,497,700
1866	3,597,700							3,597,700
1867	3,347,300							3,347,300
1868	3,646,117							3,646,117
1869	4,215,000							4,215,000
1870	5,260,745							5,260,745
1871	5,205,234							5,205,234
1872	6,293,194							6,293,194
1873	9,893,786							9,893,786
1874	10,926,945							10,926,945
1875	8,787,514	3,000						8,790,514
1876	9,120,669	12,000						9,132,669
1877	13,337,363	13,000						13,350,363
1878	15,381,641	15,227						15,396,868
1879	19,894,288	13,543						19,907,831
1880	26,245,571	40,552						26,286,123
1881	27,561,376	99,862						27,661,238
1882	30,221,261	128,636						30,349,897
1883	23,306,776	142,857						23,449,633
1884	23,956,438	262,000						24,218,438
1885	21,533,785	325,000	36,178					21,894,963
1886	26,549,827	377,145	1,064,025					27,990,997
1887	22,878,241	678,572	4,650,375	76,295				28,283,483
1888	16,941,397	690,333	9,682,683	297,612				27,612,025
1889	22,355,225	303,220	12,186,564	316,476	500	48	1,460	35,163,493

Production of petroleum fields in each year from 1859 to 1907—Continued.

Year.	Appalachian.	California.	Lima-Indiana.	Colorado-Wyoming.	Mid-Continent.	Gulf.	Illinois.	Total.
1890	30,073,307	307,360	15,078,378	368,842	1,200	54	900	45,830,041
1891	35,848,777	323,600	17,452,612	665,480	1,430	54	675	54,292,628
1892	33,432,377	385,049	15,867,675	824,000	5,080	45	521	50,514,747
1893	31,365,890	470,179	15,982,097	594,390	18,010	50	400	48,431,016
1894	30,783,424	705,969	17,296,510	518,115	40,130	60	300	49,344,508
1895	30,960,639	1,208,482	20,236,741	441,687	44,467	50	200	52,892,266
1896	33,971,902	1,252,777	25,255,870	364,328	115,141	1,450	250	60,961,718
1897	35,230,271	1,903,411	22,805,033	388,584	147,648	65,975	500	60,541,422
1898	31,717,425	2,257,207	20,321,323	450,858	616,600	546,070	360	55,909,843
1899	33,068,356	2,642,095	20,225,356	395,838	738,183	669,013	360	57,739,201
1900	36,295,433	4,324,484	21,759,290	322,835	917,225	836,039	200	64,455,506
1901	33,618,171	8,786,330	21,933,379	465,920	989,696	4,393,658	250	70,187,404
1902	32,018,787	13,984,268	23,356,626	403,154	988,720	18,632,275	200	89,384,030
1903	31,558,248	24,382,472	24,080,264	492,885	1,573,085	18,873,343	....	100,960,297
1904	31,406,567	29,649,434	24,689,184	513,305	6,186,629	25,200,371	3,500	117,650,900
1905	29,366,960	33,427,473	22,294,171	284,602	12,533,777	37,046,605	181,084	135,234,762
1906	27,741,472	33,098,598	17,554,661	334,582	22,836,553	21,645,425	4,397,050	127,608,341
1907	25,342,137	39,748,375	13,121,094	341,190	46,846,267	16,636,610	24,281,973	166,317,646
Total	947,156,953	201,962,510	386,932,089	8,961,068	94,596,341	144,547,195	28,870,183	[a] 1,813,028,339

[a] Michigan and Missouri not included.

The production recorded above has resulted from the drilling of 287,922 wells, of which 232,982 were productive and 54,940 were dry holes. A distribution of these wells by fields is shown in the following table:

Wells drilled in petroleum fields in each year from 1859 to 1907.

Year.	Appalachian.		California.		Lima-Indiana.		Colorado-Wyoming.		Mid-Continent.		Gulf.		Illinois.		Total.	
	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.
1859	2	1													2	1
1860	49	39													49	39
1861	78	61													78	61
1862	92	72													92	72
1863	137	108													137	108
1864	226	180													226	180
1865	474	375													474	375
1866	442	350													442	350
1867	618	570													618	570
1868	928	208													928	208
1869	1,500	[a]700													1,500	700
1870	1,664	[a]800													1,664	800
1871	1,470	[a]900													1,470	900
1872	1,183	[a]400													1,183	400
1873	1,263	[a]300													1,263	300
1874	1,317	[a]200													1,317	200
1875	2,398	[a]360	2												2,400	360
1876	2,920	438													2,920	438
1877	3,939	658	1												3,940	658
1878	3,064	328													3,064	328
1879	3,048	148	1												3,049	148
1880	4,217	144	3												4,220	144
1881	3,880	182	3												3,883	182
1882	3,304	179	3												3,307	179
1883	2,847	261	3												2,850	261
1884	2,265	270	4												2,269	270
1885	2,761	359	3		[a]50	[a]5									2,814	364
1886	3,478	525	5		[a]100	[a]10									3,583	585
1887	1,660	422	15		[a]300	[a]30	6								1,981	452
1888	1,505	371	45	30	531	27	46	24							2,127	452
1889	5,768	949	[a]10	4	704	4	14	8	4		2		5		6,507	965

[a] Estimated.

Wells drilled in petroleum fields in each year from 1859 to 1907—Continued.

Year.	Appalachian.		California.		Lima-Ohio.		Colorado-Wyoming.		Mid-Continent.		Gulf.		Illinois.		Total.	
	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.	Completed.	Dry.
1890	6,358	1,049	[a]10	5	1,969	193	2	....	8	2	....	....	....	....	8,347	1,249
1891	3,388	664	[a]40	[a]15	1,639	265	2	....	32	18	....	....	....	....	5,101	962
1892	1,968	462	[a]60	[a]20	1,741	259	2	....	....	....	....	....	....	....	3,771	741
1893	1,980	443	[a]75	[a]25	2,111	314	4	....	....	....	....	....	....	....	4,170	782
1894	3,763	875	[a]75	[a]20	3,661	565	2	....	50	16	....	....	....	....	7,551	1,476
1895	7,136	1,588	[a]100	[a]25	5,756	730	2	....	75	6	....	....	....	....	13,069	2,349
1896	7,824	1,901	[a]175	[a]30	5,638	708	34	18	137	78	....	....	....	....	13,808	2,735
1897	6,072	1,580	[a]200	[a]40	3,172	514	43	25	[a]10	5	41	6	....	....	9,538	2,170
1898	4,792	1,269	[a]275	[a]50	3,068	384	103	30	[a]12	[a]4	374	32	....	....	8,644	1,769
1899	8,752	1,920	[a]300	[a]60	4,616	498	33	4	[a]15	[a]5	268	90	....	....	13,984	2,577
1900	8,845	2,160	[a]500	[a]100	5,738	662	31	13	[a]30	[a]10	373	98	....	....	15,517	3,043
1901	7,709	2,118	1,116	209	4,911	590	35	16	[a]50	[a]20	551	130	....	....	14,372	3,083
1902	7,722	2,131	422	102	6,460	725	10	....	293	37	[a]500	[a]100	....	....	15,407	3,095
1903	8,474	2,214	398	75	7,758	675	20	8	1,290	264	[a]425	[a]105	....	....	18,365	3,341
1904	8,859	2,383	458	158	6,897	623	25	10	3,557	475	463	186	2	....	20,261	3,835
1905	7,450	2,251	252	8	3,500	395	[a]25	[a]10	4,043	546	861	287	600	32	16,731	3,529
1906	7,568	1,934	174	7	2,743	304	[a]30	[a]12	3,876	501	1,081	352	3,585	500	19,057	3,610
1907	7,205	1,923	309	11	1,564	252	[a]35	[a]12	4,720	392	1,051	276	4,988	728	19,872	3,594
Total	174,362	39,723	5,037	994	74,647	8,732	504	190	18,202	2,379	5,990	1,662	9,180	1,260	287,922	54,940

[a] Estimated.

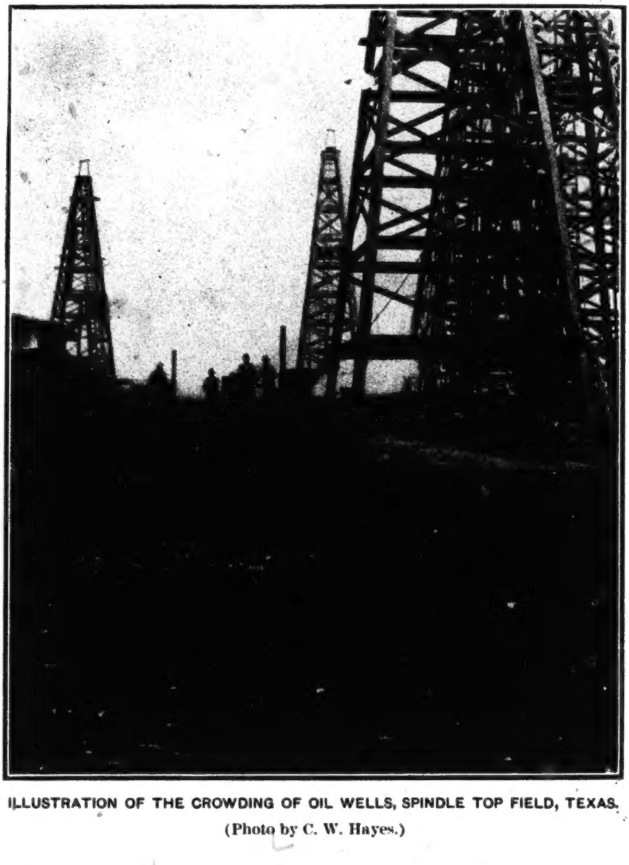


ILLUSTRATION OF THE CROWDING OF OIL WELLS, SPINDLE TOP FIELD, TEXAS.
(Photo by C. W. Hayes.)

Total number of wells in operation in petroleum fields in each year from 1859 to 1907.

Year.	Appalachian.	California.	Lima-Indiana.	Colorado-Wyoming.	Mid-Continent.	Gulf.	Illinois.	Total.
1859	1	....	....	....	....	....	....	1
1860	11	....	....	....	....	....	....	11
1861	28	....	....	....	....	....	....	28
1862	48	....	....	....	....	....	....	48
1863	77	....	....	....	....	....	....	77
1864	123	....	....	....	....	....	....	123
1865	222	....	....	....	....	....	....	222
1866	313	....	....	....	....	....	....	313
1867	351	....	....	....	....	....	....	351
1868	1,058	....	....	....	....	....	....	1,058
1869	1,838	....	....	....	....	....	....	1,838
1870	2,673	....	....	....	....	....	....	2,673
1871	3,197	....	....	....	....	....	....	3,197
1872	3,481	....	....	....	....	....	....	3,481
1873	4,752	....	....	....	....	....	....	4,752
1874	5,821	....	....	....	....	....	....	5,821
1875	7,135	2	....	....	....	....	....	7,137
1876	8,817	2	....	....	....	....	....	8,819
1877	11,234	3	....	....	....	....	....	11,237
1878	13,400	3	....	....	....	....	....	13,403
1879	15,517	4	....	....	....	....	....	15,521
1880	18,627	7	....	....	....	....	....	18,634
1881	21,158	10	....	....	....	....	....	21,168
1882	22,245	13	....	....	....	....	....	22,258
1883	22,349	16	....	....	....	....	....	22,365
1884	21,063	20	....	....	....	....	....	21,083
1885	20,729	23	[a] 45	....	....	....	....	20,797
1886	20,782	26	[a] 135	....	....	....	....	20,943
1887	17,947	37	[a] 405	6	....	....	....	18,395
1888	15,433	48	909	28	....	....	....	16,418
1889	17,127	51	1,600	34	4	2	5	18,832
1890	19,850	[a] 53	3,385	36	10	2	5	23,341
1891	20,579	[a] 74	4,759	38	24	2	5	25,481
1892	19,683	[a] 111	6,196	40	24	2	5	26,061
1893	18,267	[a] 156	7,903	44	24	2	5	26,401
1894	19,717	[a] 191	10,829	40	58	2	4	30,841
1895	24,131	[a] 251	15,251	18	127	2	4	39,784
1896	25,235	[a] 390	19,481	30	176	2	4	45,318
1897	24,418	[a] 545	20,363	46	167	37	4	45,580
1898	25,217	[a] 745	21,693	117	175	377	4	48,328
1899	30,543	[a] 945	24,329	144	185	555	4	56,705
1900	35,691	[a] 1,295	27,608	158	171	830	4	65,757
1901	38,594	2,152	28,833	175	132	1,216	4	71,106
1902	38,637	2,397	29,542	183	329	[a] 1,274	4	72,366
1903	38,974	2,575	31,695	179	1,350	[a] 1,416	....	76,189
1904	40,958	2,715	30,235	176	4,424	1,418	2	79,928
1905	42,634	[a] 2,734	26,315	[a] 118	7,911	1,571	570	81,853
1906	41,436	2,661	18,901	[a] 107	10,270	1,900	3,655	78,930
1907	40,033	2,559	13,130	[a] 112	14,568	2,355	7,913	80,670

[a] Estimated.

LIFE OF A WELL.

Varying with the compactness of the "pay sand" and with the pressure of the gas accompanying the petroleum, the productive life of wells varies between the extreme limits of a few months on the one hand to more than twenty years on the other. In many regions in Pennsylvania the hard and compact sandstones have resulted in wells of unusually long life, such wells having an initial production of 50 to 500 barrels in the first twenty-four hours and "settling down" to a comparatively steady production of perhaps one-tenth of that amount. This has continued for years with gradual decline, and after even twenty years many of such wells are still being pumped, with a production declining to one-tenth of a barrel per day. The other extreme, of short-lived wells, is represented by the Spindle Top type, where, from very loose sands, wells have spouted many thousands of barrels in the first twenty-four hours, have shown a correspondingly rapid decline, and have become exhausted and been abandoned within six months to four years from the time when first drilled. The experience of petroleum producers in Pennsylvania has shown seven years to be a fair average life of a well.

Adopting this average for the Appalachian, Lima-Indiana, Illinois, and Mid-Continent fields, four years for Texas, six years for California, and seven years for the minor petroleum fields, tables have been computed showing the probable number of active wells which contributed to each year's production. This has been done by adding to the existing wells all the new productive wells drilled in each year and subtracting all wells when they reached the prescribed age limit. From these tables the average daily yield of the wells of each region has been estimated:

Average production per well per day in each field from 1859 to 1907.

[Barrels of 42 gallons.]

Year.	Appalachian.	California.	Lima-Indiana.	Colorado-Wyoming.	Mid-Continent.	Gulf.	Illinois.	Average.
1859	5.48							5.48
1860	124.19							124.19
1861	206.81							206.81
1862	174.47							174.47
1863	92.91							92.91
1864	47.01							47.01
1865	30.82							30.82
1866	31.49							31.49
1867	26.13							26.13
1868	9.44							9.44
1869	6.28							6.28
1870	5.39							5.39
1871	4.46							4.46
1872	4.94							4.94
1873	5.70							5.70
1874	5.14							5.14
1875	3.37	4.11						3.74
1876	2.83	16.39						9.61
1877	3.25	11.87						7.56
1878	3.14	13.91						8.53
1879	3.51	9.28						6.40
1880	3.86	15.83						9.85
1881	3.57	27.36						15.47
1882	3.72	27.11						15.42
1883	2.86	24.46						13.66
1884	3.11	35.74						19.43
1885	2.85	38.70	2.20					14.58
1886	3.50	39.74	21.59					21.61
1887	3.49	50.24	31.46	34.83				30.01
1888	3.00	39.30	29.10	29.04				25.11
1889	3.58	16.28	20.75	25.50	.35	.07	.80	9.62
1890	4.15	15.88	12.20	28.07	.34	.08	.50	8.75
1891	4.77	11.98	10.05	47.98	.16	.08	.36	10.77
1892	4.64	9.50	7.00	56.29	.24	.06	.28	11.14
1893	4.70	8.26	5.54	37.01	2.05	.07	.22	8.26
1894	4.23	10.12	4.38	35.49	1.89	.08	.20	8.06
1895	3.52	13.19	3.64	67.23	.96	.07	.13	12.08
1896	3.68	8.78	3.54	33.10	1.79	1.98	.18	7.38
1897	3.95	9.57	3.07	23.14	2.43	4.89	.35	6.77
1898	3.45	8.30	2.57	10.56	9.65	3.97	.25	5.54
1899	2.97	7.66	2.28	7.53	10.93	3.30	.25	4.99
1900	2.79	9.15	2.16	5.60	14.70	2.76	.13	5.33
1901	2.39	11.19	2.08	7.29	20.54	9.90	.18	7.65
1902	2.27	15.99	2.17	6.04	8.22	40.07	.13	10.70
1903	2.22	25.94	2.07	7.54	3.19	36.51		11.07
1904	2.10	29.84	2.23	7.97	3.82	48.56	4.80	14.19
1905	1.89	33.49	2.32	8.93	4.34	64.61	.87	16.64
1906	1.83	34.07	2.54	8.57	6.09	31.21	3.30	12.52
1907	1.73	42.56	2.74	8.35	8.81	19.35	8.37	13.13
Average	18.11	20.47	7.73	23.62	5.29	14.08	1.12	

DURATION.

PRODUCTION CURVE.

The rate of petroleum production, graphically portrayed in the curve already referred to, shows that beginning with 1860 as much petroleum has been produced in each nine years as the entire product preceding this nine years. Continuing this rate of increase the next nine years would produce 1,800,000,000 barrels, making the total amount extracted up to 1916 3,600,000,000 barrels. In 1925 the amount extracted would reach 7,200,000,000, and in 1934 14,400,000,000 barrels, and nine years more, 1943, would bring the total to almost the maximum amount estimated as obtainable from the present fields. Concerning the probability of such a rate of increase in production, one must consider the causes for the great increase in past years. The vital factor has been the ease with which any quantity of oil could be sold for cash at any time and for prices ordinarily much above the cost of production. This ready market has not been seriously disturbed even by the greatly increased production of the past few years. The second reason is based upon the liquid character of the product. With the discovery of each new field the territory is divided into many leaseholdings, frequently small in size. In pumping from one lease petroleum is apt to flow in from a rival interest. It is therefore necessary for each lessee to "get his share" before it flows away to drained territory. It is impossible to prevent the consequent rapid depletion of a field without a combination of all the interests, or by limiting by statute the amount that each producer shall extract per acre within a specified time. General industrial conditions have had little effect in regulating the production of petroleum, as has been the case with coal. The purchaser for cash has always been on hand. Even if the price paid has been low, it has been above the cost of production. The surplus has been readily marketed abroad, or burned as a substitute for coal.

Oil's independence of industrial conditions is also shown by the inability of the production to respond to greatly increased trade demand. It requires the development of new territory to greatly increase the production. Otherwise the developed fields rapidly fall into the stage of decline, which is more or less rapid as the oil sands are loose or compact. Without the opening of new territory there is no probability of continuing the indicated rate of increase. The production of the present year could not be maintained beyond a very few years. The duration of the supply will thus be extended, but with a production inadequate to legitimate demands, as the production in the past has been excessive.

Under conditions of an insufficient supply, the relations of price to production must more closely follow supply and demand, the conditions governing which have been pointed out in connection with our better known supply of coal, but there must always remain the exceptional feature of rival producers vieing in the extraction of petroleum from the same reservoir.

RAPIDLY DECLINING FIELDS.

The production tables show that in seventeen years Pennsylvania and New York have decreased to a third of their greatest output.

The decline has become quite regular, and, logically extended, will render the production negligible in ten years. The production per well per day has fallen from a maximum average of 207 barrels to 1.7 barrels, showing that increasing the number of wells is not significantly effective in stimulating the product. In fact, many very old wells are contributing to the product with as little as one-tenth of a barrel per day.

The production in West Virginia has declined to 56 per cnt of the maximum output, and new developments of great magnitude are not looked for. This State is also in the rapidly declining class.

The rate in Kentucky and Tennessee is not easily predicted, but there is no territory which has yet been proved to rank among the great producers. Ohio and Indiana are declining more rapidly at present than Pennsylvania. In Texas the decline is also rapid, and a total of only 200,000,000 barrels is estimated from the present pools. In Kansas the decline has been rapid and the production has now reached a small fraction of the previous yield and a stage where the future decline will be slower.

INCREASING TERRITORY.

Illinois and Oklahoma, in the Mid-Continent field, and California can be expectd to show greater yields. In Illinois the limitations of the new fields have not been reached, and the possibilities of considerable extensions render an increase in the yield probable for several years. The same is true in Oklahoma, particularly in the so-called "shallow pool."

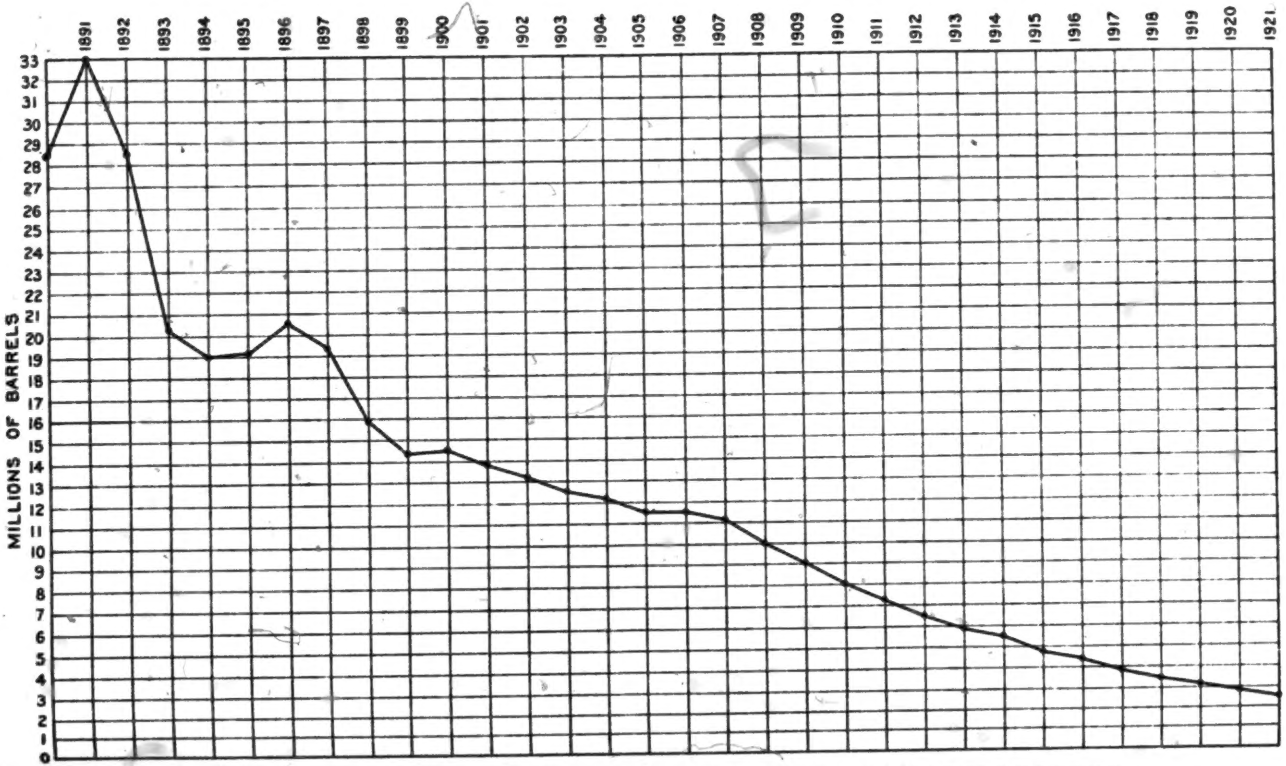
TIME OF EXHAUSTION.

Regarding the limits of time within which the present supply will be exhausted, it is clear that considering the minimum quantity of petroleum in the United States as 15,000,000,000 barrels, and continuing the present rate of increase in production, the supply would be exhausted about 1935. If the present annual production were continued without increase, 90 years would be required to exhaust this estimated minimum quantity. A reasonable view of the situation makes it probable that the present annual rate of production will be increased slightly through the developments of Illinois, Oklahoma, and California, but that within a very few years a marked decline will be noted, and this will continue with increasing value for the oil product and an insufficient quantity for the legitimate demands of the industry after another decade, and that the production, on a reduced scale, will continue for a long time, but in an amount unsatisfactory to industrial necessity, except as supplemented from new fields.

NATURE AND EXTENT OF WASTE IN THE EXTRACTION OF PETROLEUM.

STORAGE.

Waste, as understood in the natural-gas industry, has been markedly absent with petroleum. Very rarely has it proved impossible to furnish storage for some exceptionally prolific gusher. In 1907 lack



DECLINE IN PRODUCTION OF THE NEW YORK AND PENNSYLVANIA OIL FIELDS AND ITS PROBABLE RATE IN THE FUTURE.

of storage in the Mid-Continent field resulted in wasting a large amount of petroleum, estimated at 1 per cent of the total production, for which no storage was available. A similarly exceptional waste resulted in 1901 from the unexpected gushers in the Spindle Top pool in Texas.

LACK OF FORESIGHT ABROAD.

The record of the United States in providing sufficient storage in steel tanks is far better than that of the other petroleum fields of the world. In Russia lack of foresight in opening unusually strong gushers has not only led to repeated enormous waste of petroleum, but to fires which have involved the destruction of large cities. Nowhere else in the world have the emergencies of the petroleum production been met with the keen foresight and prompt treatment characteristic of the United States.

EVAPORATION.

Another form of waste of petroleum products of Europe and of the East, which has been avoided in the United States, is evaporation of gasoline and of similar light products when the petroleum is exposed to the air in open tanks. These light products form the most valuable portion of petroleum. A thin layer of any ordinary light crude petroleum will become heavy and valueless by exposure to the sun for a single day. This has been a source of great loss in the open earthen tanks which have been much used in Russia. In the United States, on the other hand, only under very exceptional circumstances has the earthen tank been used, and then only pending the completion of steel tankage. The rapidity with which steel tanks, often holding as much as 55,000 barrels, have been constructed, to the extent of farms of these tanks, is a remarkable tribute to the engineering skill of the oil-transportation companies. It is due, also, to the conditions of the iron industry, which make it possible to furnish suitable steel promptly for such emergencies. On an average, one tank per day was completed in the Mid-Continent field in 1907.

WASTE IN THE USE OF PETROLEUM.

The principal waste in the petroleum industry is connected with its utilization. In the face of an approaching scarcity, the use of petroleum should be limited to the purposes for which it is essential and for which no other material can be substituted.

ESSENTIAL USES.

Petroleum may be regarded as indispensable for the lighting of isolated houses, and for every small establishment not in connection with a gas or electric supply. The prices at which lamp oils can be sold are lower than the prices of any substitute under isolated conditions. The economic necessity, therefore, of securing the greatest amount of illuminating oil from crude petroleum is evident.

ABSOLUTE NECESSITY OF OIL FOR LUBRICATION.

A still more essential use of petroleum is for lubricating all bearings in every kind of machinery. This is necessary in the development of power by any means. The following table gives some indication of the amount of lubricating oil consumed in various kinds of power production. At least one-half pint of lubricating oil is used for every ton of coal converted into power, and when this power is carried further to its ultimate uses, such as the moving of railroad cars, and when account is taken of the machinery depending on hand power, including sewing machines, clocks, watches, etc., this necessary oil is probably doubled in amount. The conservation, therefore, of a proportionate amount of lubricating oil, consistent with all industrial activity, must become a part of the general plan for civilized progress. It should be noted that from 10 to 15 per cent is as large an amount of lubricating oil as is now obtained from crude petroleum.

Average amount of lubricating oil required for power.

	Gallon of oil per ton of coal.	Gallon of oil per horse-power day.	
Street railway power station	0.168	0.0021	Including crank case, cylinder, and engine oil.
Niagara Falls power house	.024	.0003	Doubtless supplemented by water lubrication.
Fleet of 167 steam vessels, total indicated horsepower, 480,900.	.209	.0025	Machine and cylinder oil.
New England industrial plants:			
No. 1	.400	.0048	Cylinder oil.
No. 2	.200	.0024	
No. 3	.670	.0080	
No. 4	.500	.0060	
Average	.310	.0037	

UNNECESSARY USES.

In 1907 there were 18,855,691 barrels of crude petroleum burned as fuel in locomotives, and a large proportion of the California production was used for the development of power, principally by burning it for the generation of steam. Whenever a large increase is made in the production of petroleum with a corresponding decrease in price, the producers are grateful for any outlet for their oil and sell it for such low-grade uses, in which it brings not more than one hundredth part and has brought as low as one thousandth part of the maximum price for high-grade petroleum products. Much of this crude petroleum, had it remained stored in the ground, could later have been converted into far more valuable products. Much petroleum has been used for oiling roads. The skillful application of petroleum residues to poor road surfaces has proved so effective that this use is justifiable, but the use of crude petroleum for such purposes can seldom be considered in any other light than as a waste, especially as coal-tar residues and waste products of the coking and illuminating-gas industry serve this purpose well enough.

EXPORTS.

The greatest waste of petroleum has been in exporting crude petroleum and petroleum products to foreign countries. The necessity for it has been due to the sudden increase of production, due to the discovery and immediate development of the larger fields, and only by this means has it been possible for the producers to continue the practice of furnishing a constant market for petroleum, wherever produced. This immediate purchase of the product has meant a gain of millions of dollars to the producers.

METHODS OF PREVENTING OR LESSENING WASTE IN THE PETROLEUM INDUSTRY.

CHECKING UNNECESSARY PRODUCTION.

At present, more petroleum is being produced than is necessary for the legitimate demands of the industry. Within ten years the present fields will be unable profitably to produce enough for these legitimate requirements. Inasmuch as the lands now owned by private interests are leased by rival concerns, it is impossible to prevent each rival from producing petroleum as rapidly as he desires. The only direction in which production can be checked is with the petroleum contained in public lands. Offering such public land for entry at a nominal price is nothing more than temptation to the private citizen to waste petroleum by overproduction, since lands yielding hundreds of dollars per acre in this product can be obtained for a nominal sum. Every acre of public land believed to contain supplies of petroleum or natural gas should be withdrawn from every form of entry and should be subjected to an equitable system of lease. By this means undoubtedly a large amount of petroleum would be reserved for use when the supply becomes inadequate to industrial demands. It should be noted that since the advance copies of this report appeared in the public press, the petroleum producers of Oklahoma have arranged to reduce production in that State.

BETTER COMBUSTION.

The use of petroleum as a form of power is justified on the Pacific coast, provided attention is given to securing the maximum amount of power per unit of oil. This is not consistent with burning oil under stationary boilers for the production of steam, but prompt study should be given to the development of internal-combustion engines capable of using crude petroleum or, more particularly, less valuable residuum. It should be noted that private enterprise has already done much for the successful solution of this problem.

HOW SUPPLIES OF PETROLEUM MAY BE EXTENDED.

PREVENTION OF WASTE IN EXTRACTION AND IN USE.

Legislation tending to the capping of gas wells in petroleum fields, to preserve the pressure, and to prevent the unnecessary encroachment of water, should be extended to all States where petroleum is produced. After the practical exhaustion of the field by this encroachment of water, the remaining petroleum can frequently be washed into smaller but still profitable pools—a system which is already intelligently used in this country.

DISCOVERY AND DEVELOPMENT OF SUBSTITUTES.

Alcohol from grain, potatoes, and waste products can be used in the place of petroleum as an illuminant and for power in place of gasoline whenever the necessity arises. No practical substitute is known for mineral lubricating oils. Animal and vegetable oils are excluded as entirely too expensive. The production of artificial petroleum from various vegetable and animal waste products has received sufficient study to indicate the possibility of good results if scientific research is encouraged in this direction.

NECESSITY OF SCIENTIFIC RESEARCH.

The most practical recommendation seems to be the encouragement of scientific research in the study of the conditions of occurrence of petroleum in the earth, in order to lessen the expense of discovery of new pools. A second line of scientific research of even greater value should include fundamental studies of the nature of all kinds of petroleum, with a view to converting less valuable varieties into higher grades and to producing greater proportions of the absolutely necessary lubricating oils from crude petroleum. Such scientific study should be initiated at once to be of benefit when the present petroleum supply becomes inadequate.

RECOMMENDATIONS.

Three conclusions are self-evident from this report.

First. It is absolutely necessary for the preservation of an adequate supply of petroleum that all public lands where petroleum is probable should at once be withdrawn from entry.

Second. A general investigation of the conditions of accumulation of petroleum and its geographic distribution should be undertaken in order that the petroleum-bearing public lands may be selected.

Third. Fundamental scientific study of the nature of petroleum, especially with a view to securing the greatest yields of the most valuable constituents and even for transmuting one oil into another, is required for its most intelligent use.

NATURAL-GAS RESOURCES OF THE UNITED STATES.

By David T. Day,
United States Geological Survey.

THE GAS FIELDS.

DISTRIBUTION.

The conditions favorable to the accumulation of gas reservoirs are in general the same as for petroleum. The two usually overlap. More or less gas is always found dissolved in crude petroleum, and the amount of gas obtained at a given pressure from a sand of slight thickness leads to the belief that the gas is dissolved in the petroleum under pressure, in a manner similar to the solution of carbonic acid in water. Reservoirs filled with dry gas are often found—almost always in the neighborhood of petroleum fields—though beds of coal often yield natural gas, even when far from oil wells, as in the anthracite mines of Pennsylvania, where gas is found more than 100 miles distant from any petroleum pool.

AREAS.

The areas shown on the petroleum and gas map, accompanying this report, comprise the regions in which either natural gas or petroleum is the more valuable product. The limits of these areas have been revised since the map was published, and they now show the following measurements in square miles:

State.	Square miles.	State.	Square miles.	State.	Square miles.
Alabama	40	Missouri	70	South Dakota	80
California	310	Montana	40	Texas	130
Colorado	80	New York	550	Utah	40
Illinois	50	Ohio:		Washington	70
Indiana	2,460	Eastern	110	West Virginia	1,000
Kansas	550	Western	165	Wyoming	120
Kentucky	290	Oklahoma	1,000		
Louisiana	110	Oregon	20	Total	10,055
Michigan	40	Pennsylvania	2,730		

PRESSURE.

Estimates of the total yield, in cubic feet, which can be expected from the gas pools are ordinarily obtained by measuring the pressure with a Pitot tube, calculating by a simple formula the cubic feet per day, and observing the rate of decline.

The closed or rock pressures in various fields, in so far as reliable records are available, are given in the following table for various years:

Pressure of natural gas in various fields at various dates.

[In pounds per square inch.]

	Illinois.	Indiana.	Kansas.	Kentucky.	New York.	Ohio.	Oklahoma.	Pennsylvania.	Texas.	West Virginia.
1885	400-450					450		150-575		
1886	125	325-400	110			400		200-460		550-650
1887		320-340				[a] 750 [b] 650		200-380		
1888	300	325		125		[b] 450				
1889		325			400	250-390				
1890					240	170-275				1,000
1893		280								
1894	60	260	200					250		
1895	40	240		[c] 60 [d] 250-300		[b] 50-150		150		
1896	25	220	100	285-300		[a] 750 [b] 45		85		600-900
1897		195	250		1,500	[b] 30				100-1,100
1898		165								600-1,200
1899	[e] 3-30	150	300-325		200					1,200
1900		110	[f] 310-320 [g] 150			[a] 300-400 ([b] [h])				1,200
1901		80							[i] 250	1,000-1,300
1902		50				[a] 100 [j] 800				1 000-1,250
1903								400		850-1,250
1904		155 [k] 305-400	330-650							
1906	150-435	22-156	90-282		45-335	121-382	217-468	41-486		144-[illegible]

[a] Lancaster.
[b] Northwestern Ohio.
[c] Western Kentucky.
[d] Eastern Kentucky.
[e] Bureau County.
[f] Allen County.
[g] Neosho County.
[h] Reduced to almost no pressure.
[i] Beaumont.
[j] Homer.
[k] Southern Indiana.

The paucity of actual data is evident from the table above. It is useful only in showing the generally rapid decline of the high pressures.

PRODUCTION.

The following tables show the value of the natural gas thus far produced. It has been possible only in the last two years to determine the quantity, in addition to the value of gas produced, but this shows that the quantity produced, as well as the price, is increasing.

Approximate value of natural gas produced in the United States, 1882-1907, by States.

State.	1882.	1883.	1884.	1885.	1886.	1887.
Pennsylvania	$75,000	$200,000	$1,100,000	$4,500,000	$9,000,000	$13,749,500
New York				196,000	210,000	333,000
Ohio				100,000	400,000	1,000,000
West Virginia				40,000	60,000	120,000
Illinois				1,200	4,000	
Indiana					300,000	600,000
Kansas					6,000	
Other	140,000	275,000	360,000	20,000	32,000	15,000
Total	215,000	475,000	1,460,000	4,857,200	10,012,000	15,817,500

Approximate value of natural gas produced in the United States, 1882-1907, by States—Continued.

State.	1888.	1889.	1890.	1891.	1892.	1893.
Pennsylvania	$19,282,375	$11,593,989	$9,551,025	$7,834,016	$7,376,281	$6,488,000
New York	332,500	530,026	552,000	280,000	216,000	210,000
Ohio	1,500,000	5,215,669	4,684,300	3,076,325	2,136,000	1,510,000
West Virginia	120,000	12,000	5,400	35,000	70,500	123,000
Illinois	....	10,615	6,000	6,000	12,988	14,000
Indiana	1,320,000	2,075,702	2,302,500	3,942,500	4,716,000	5,718,000
Kansas	....	15,873	12,000	5,500	40,795	50,000
Missouri	....	35,687	10,500	1,500	3,775	2,100
California	....	12,680	33,000	30,000	55,000	62,000
Kentucky and Tennessee	....	2,580	30,000	38,993	43,175	68,500
Texas and Alabama	....	1,728	....	....	100	50
Arkansas and Wyoming	....	375	....	250	100	100
Utah	....	....	....	....	....	500
Other	75,000	1,600,175	1,606,000	250,000	200,000	100,000
Total	22,629,875	21,107,099	18,792,725	15,500,084	14,870,714	14,346,250

State.	1894.	1895.	1896.	1897.	1898.	1899.	1900.
Pennsylvania	$6,279,000	$5,852,000	$5,528,610	$6,242,543	$6,806,742	$8,337,210	$10,215,412
New York	240,000	241,530	256,000	200,076	229,078	294,593	335,367
Ohio	1,276,100	1,255,700	1,172,400	1,171,777	1,488,308	1,866,271	2,178,234
West Virginia	395,000	100,000	640,000	912,528	1,334,023	2,335,864	2,959,032
Illinois	15,000	7,500	6,375	5,000	2,498	2,067	1,700
Indiana	5,437,000	5,203,200	5,043,635	5,009,208	5,060,969	6,680,370	7,254,539
Kansas	86,600	112,400	124,750	105,700	174,640	332,592	356,000
Missouri	4,500	3,500	1,500	500	145	290	547
California	60,350	55,000	55,682	50,000	65,337	86,891	79,083
Kentucky and Tennessee	89,200	98,700	99,000	90,000	103,133	125,745	....
Alabama	50	20	....	....	765	8,000	20,000
Texas							
Arkansas and Wyoming	100	100	60	40	....	....	....
Utah	500	20,000	20,000	15,050	7,875	....	....
Kentucky	....	....	....	....	....	....	286,243
Colorado	12,000	7,000	4,500	4,000	3,300	1,480	1,800
South Dakota	....	....	....	....	....	3,500	9,817
Other	59,000	50,000	50,000	20,000	20,000	....	....
Total	13,954,400	13,006,650	13,002,512	13,826,422	15,296,813	20,074,873	23,698,674

State.	1901.	1902.	1903.	1904.	1905.	1906.	1907.
Pennsylvania	$12,688,161	$14,352,183	$16,182,834	$18,139,914	$19,197,336	$18,558,245	$18,844,156
New York	293,232	346,471	493,686	522,575	623,251	672,795	766,157
Ohio	2,147,215	2,355,458	4,479,040	5,315,564	5,721,462	7,145,809	8,718,562
West Virginia	3,954,472	5,390,181	6,882,359	8,114,249	10,075,804	13,735,343	16,670,962
Illinois	1,825	1,844	3,310	4,745	7,223	87,211	143,577
Indiana	6,954,566	7,081,344	6,098,364	4,342,409	3,094,134	1,750,715	1,572,605
Kansas	659,173	824,431	1,123,849	1,517,643	2,261,836	4,010,986	4,843,019
Missouri	1,328	2,154	7,070	6,285	7,399	7,210	17,010
California	67,602	120,648	104,521	114,195	133,696	134,560	168,397
Alabama	....	....	....	14,082	14,400	150,695	
Texas	18,577	14,953	13,851				178,276
Louisiana	....	....	....	....	1,500		
Kentucky	270,871	365,356	390,301	322,104	237,290	287,501	380,176
Tennessee	....	300	300	300	300	300	300
Arkansas and Wyoming	....	....	2,460	6,515	21,135	34,500	126,582
Colorado	1,800	1,900	14,140	14,300	20,752	22,800	
South Dakota	7,255	10,280	10,775	12,215	15,200	15,400	19,500
Oklahoma	....	360	1,000	49,665	130,137	250,862	417,221
North Dakota	....	....	....	....	....	....	235
Oregon	....	....	....	....	....	....	100
Total	27,066,077	30,867,863	35,807,860	38,496,760	41,562,855	46,873,932	52,866,835

Value of natural gas consumed in the United States, 1902–1907, by States.

State.	1902.	1903.	1904.	1905.	1906.	1907.
Pennsylvania	$13,942,783	$16,060,196	$17,205,804	$19,237,218	$21,085,077	$22,917,542
Ohio	4,785,766	7,200,867	9,393,843	10,396,633	12,652,520	15,227,789
Kansas	824,431	1,123,849	1,517,643	2,265,945	4,030,776	4,853,298
Missouri	2,154	7,070	6,285	7,390		17,010
West Virginia	2,473,174	3,125,061	3,383,515	3,586,608	3,720,440	3,757,957
New York	1,723,709	1,944,667	2,222,980	2,434,894	2,654,115	3,098,535
Indiana	[a] 6,710,080	[a] 5,915,367	[a] 4,282,409	[a] 3,056,634	[a] 1,750,755	1,570,006
Kentucky	255,481	280,426	268,264	237,290	287,501	390,178
Oklahoma	360	1,000	49,665	126,028	247,282	405,942
Alabama	....	....	14,082		150,695	
Texas	14,953	13,851		14,409		178,276
Louisiana	....	....	....	1,500		
California	120,648	104,521	114,195	133,096	134,560	168,397
Illinois	1,844	3,310	4,745	7,223	87,211	142,577
Arkansas	....	2,460	6,515	21,135	34,500	126,532
Wyoming	....					
Colorado	1,900	14,140	14,300	20,752	22,800	
South Dakota	10,280	10,775	12,215	15,200	15,400	19,500
Tennessee	300	300	300	300	300	300
North Dakota	....	....	....	....	....	225
Oregon	....	....	....	....	....	100
Total	30,867,863	35,807,860	38,496,760	41,562,855	46,873,932	52,866,835

[a] A portion of this was consumed in Chicago, Ill.

Distribution of natural gas consumed in the United States in 1906, by States.

State.	Number of producers.	Consumers.		Gas consumed.		
				Domestic.		
		Domestic.	Industrial.	Quantity, M cubic feet.	Cents per M cu. ft.	Value.
Pennsylvania	309	273,184	3,307	41,135,806	22.2	$9,128,837
Ohio	409	310,175	3,316	33,049,479	24.7	8,165,597
Kansas	130	79,512	995	9,576,572	17.5	1,673,979
Missouri	19					
West Virginia	67	51,281	913	9,619,147	15.5	1,490,473
New York	143	74,538	95	8,999,871	27.7	2,495,040
Indiana	578	47,368	156	5,049,759	27.8	1,403,987
Kentucky	45	17,216	18	679,941	40.5	275,800
Oklahoma	50	8,391	202	1,446,879	11.8	170,774
Alabama	2	1	1	273,919	30.4	83,239
Louisiana	4	2,700	28			
Texas	5	702	1			
California	18	5,537	10	122,577	97.3	119,338
Illinois	66	1,429	2	359,556	22.8	82,211
Arkansas	4	1,700	4	58,500	49.1	28,711
Wyoming	3	3	4			
Colorado	3	800	11	20,500	100.0	20,500
South Dakota	13	406	10	12,900	88.4	11,400
Tennessee	3	1	1	400	25.0	100
Total	1,871	874,944	9,074	110,405,806	22.7	25,140,097

Distribution of natural gas consumed in the United States in 1906, by States—Continued.

State.	Gas consumed.					
	Industrial.			Total.		
	Quantity, M cubic feet.	Cents per M cu. ft.	Value.	Quantity, M cubic feet.	Cents per M cu. ft.	Value.
Pennsylvania	120,959,365	9.9	$11,956,240	162,095,173	13.0	$21,085,077
Ohio	41,763,083	10.7	4,486,953	74,812,562	16.9	12,652,520
Kansas	59,891,889	3.9	2,356,797	69,468,461	5.8	4,030,776
Missouri						
West Virginia	48,835,862	4.6	2,230,967	58,455,009	6.3	3,720,440
New York	1,182,551	13.4	159,075	10,182,422	26.0	2,654,115
Indiana	2,811,781	12.3	346,768	7,861,540	22.2	1,750,755
Kentucky	109,213	10.6	11,641	789,154	36.4	287,501
Oklahoma	1,961,249	3.9	76,508	3,406,128	7.2	247,282
Alabama	764,650	8.8	67,375	1,038,569	14.5	150,695
Louisiana						
Texas						
California	30,444	50.0	15,222	153,021	87.9	134,560
Illinois	50,000	10.0	5,000	409,556	21.3	87,211
Arkansas	62,000	9.3	5,789	120,500	28.6	34,500
Wyoming						
Colorado	3,067	75.0	2,300	23,567	96.7	22,800
South Dakota	10,000	40.0	4,000	22,900	67.2	15,400
Tennessee	1,600	12.5	200	2,000	15.0	300
Total	278,436,754	7.8	21,724,835	388,842,562	12.1	46,873,932

Quantity and value of natural gas produced and consumed in the United States in 1906, by States.

State.	Produced.			Consumed.		
	Quantity, M cubic feet.	Cts. per M cu. ft.	Value.	Quantity, M cubic feet.	Cts. per M cu. ft.	Value.
Pennsylvania	138,161,385	13.4	$18,558,245	162,095,173	13.0	$21,085,077
Ohio	45,436,020	15.7	7,145,809	74,812,562	16.9	12,652,520
West Virginia	119,400,392	11.5	13,735,343	58,455,009	6.3	3,720,440
Kansas	69,322,633	5.8	4,010,986	69,468,461	5.8	4,030,776
Missouri	33,560	21.5	7,210			
New York	2,547,769	26.4	672,795	10,182,422	26.0	2,654,115
Indiana	7,861,140	22.2	1,750,715	7,861,540	22.2	1,750,755
Kentucky	789,154	36.4	287,501	789,154	36.4	287,501
Oklahoma	3,520,396	7.3	259,862	3,406,128	7.2	247,282
California	153,021	87.9	134,560	153,021	87.9	134,560
Alabama	1,038,569	14.5	150,695	1,038,569	14.5	150,695
Louisiana						
Texas						
Illinois	409,556	21.3	87,211	409,556	21.3	87,211
Colorado	23,567	96.7	22,800	23,567	96.7	22,800
Arkansas	120,500	28.6	34,500	120,500	28.6	34,500
Wyoming						
South Dakota	22,900	67.2	15,400	22,900	67.2	15,400
Tennessee	2,000	15.0	300	2,000	15.0	300
Total	388,842,562	12.1	46,873,932	388,842,562	12.1	46,873,932

Quantity and value of natural gas consumed in the United States in 1907, by States.

State.	Number of producers.	Consumers.		Gas consumed.		
				Domestic.		
		Domestic.	Industrial.	Quantity, M cu. ft.	Cents per M cu. ft.	Value.
Pennsylvania	344	295,115	2,812	44,840,748	24.2	$10,846,[illegible]
Ohio	468	380,489	5,476	41,970,198	24.4	10,228,[illegible]
Kansas	196	146,327	1,606	16,022,597	14.8	2,374,[illegible]
West Virginia	105	53,807	1,000	9,807,000	16	1,[illegible]
New York	208	83,805	155	10,466,829	27.9	2,918,[illegible]
Indiana	687	46,210	218	4,480,499	28.7	1,284,[illegible]
Oklahoma	107	11,938	277	1,262,808	19.3	244,[illegible]
Kentucky	38	19,270	239	1,028,898	31.5	324,[illegible]
Alabama	2	600	4	343,261	30.7	105,[illegible]
Louisiana	5	3,000	38			
Texas	8	1,250	6			
California	51	6,346	37	97,245	102.2	99,[illegible]
Illinois	128	2,126	61	344,304	22.7	78,284
Arkansas	6	3,899	35	185,405	40.5	75,[illegible]
Colorado	3	1,091	21			
Wyoming	4	6	8			
South Dakota	18	829	5	22,500	53.8	12,100
Missouri	26	259	12	41,340	25	10,335
Tennessee	4	1	1	400	25	100
North Dakota	3	3	....	940	25	235
Oregon	1	1	....	400	25	100
Total	2,407	1,055,181	13,006	130,915,372	23	30,170,[illegible]

State.	Gas consumed.					
	Industrial.			Total.		
	Quantity, M cu. ft.	Cents per M cu. ft.	Value.	Quantity, M cu. ft.	Cents per M cu. ft.	Value.
Pennsylvania	119,700,431	10.1	$12,070,625	164,541,179	13.9	$22,917,847
Ohio	41,001,570	12.2	4,998,801	82,971,768	18.4	15,227,780
Kansas	58,556,098	4.2	2,478,537	74,577,695	6.5	4,853,[illegible]
West Virginia	44,363,520	4.9	2,190,066	54,170,520	6.9	3,757,[illegible]
New York	1,390,925	12.9	179,716	11,857,754	26.1	3,098,[illegible]
Indiana	2,134,705	13.4	286,445	6,615,204	23.7	1,570,665
Oklahoma	3,552,828	4.6	162,892	4,815,636	8.5	406,942
Kentucky	274,260	20.3	55,806	1,303,158	29.2	380,176
Alabama						
Louisiana	944,473	7.7	73,004	1,287,734	13.8	178,278
Texas						
California	133,099	51.8	69,021	230,344	73.1	168,397
Illinois	810,040	8.1	65,293	1,154,344	12.4	143,577
Arkansas						
Colorado	581,583	8.8	51,400	766,988	16.5	126,562
Wyoming						
South Dakota	15,000	49.3	7,400	37,500	52	19,500
Missouri	66,750	10	6,675	108,090	15.7	17,010
Tennessee	1,600	12.5	200	2,000	15	300
North Dakota	....	....	....	940	25	235
Oregon	....	....	....	400	25	100
Total	273,525,882	8.3	22,695,883	404,441,254	13.07	52,866,835

Quantity and value of natural gas produced and consumed in the United States in 1907, by States.

State.	Produced.			Consumed.		
	Quantity, M cu. ft.	Cents per M cu. ft.	Value.	Quantity, M cu. ft.	Cents per M cu. ft.	Value.
Pennsylvania	135,516,015	13.9	$18,844,156	164,541,179	13.9	$22,917,547
West Virginia	122,687,236	13.6	16,670,962	54,170,520	6.9	3,757,977
Ohio	52,040,996	16.8	8,718,862	82,971,768	18.4	15,227,780
Kansas	74,526,300	6.5	4,843,019	74,577,695	6.5	4,853,228
Indiana	6,624,204	23.7	1,572,605	6,615,204	23.7	1,570,605
New York	3,287,974	23.3	766,157	11,867,754	26.1	3,098,533
Oklahoma	4,867,081	8.5	417,221	4,815,636	8.5	409,942
Kentucky	1,303,158	29.2	380,176	1,303,158	29.2	380,176
Alabama Louisiana Texas	1,287,734	13.8	178,276	1,287,734	13.8	178,276
California	230,344	73.1	168,397	230,344	73.1	168,397
Illinois	1,154,344	12.4	143,577	1,154,344	12.4	143,577
Arkansas Colorado Wyoming	766,988	16.5	126,582	766,988	16.5	126,582
North Dakota	940	25.0	235	940	25.0	235
Missouri	108,090	15.7	17,010	108,090	15.7	17,010
Tennessee	2,000	15.0	300	2,000	15.0	300
South Dakota	37,500	52.0	19,500	37,500	52.0	19,500
Oregon	400	25.0	100	400	25.0	100
Total	404,441,254	13.07	52,866,835	404,441,254	13.07	52,866,835

PROBABLE DURATION OF THE SUPPLY OF NATURAL GAS.

The duration of high pressures in the known fields is very short. There is no probability of the pressures exceeding 100 pounds per well after ten years. The rate of decline is a peculiar one. At first very rapid, it would be expected that the decline in pressure would follow a simple rate, but it does not. Many wells are still showing a slight but appreciable yield by pumping them after the pressure became negligible. The yield from these low-pressure wells is surprisingly persistent. Evidently the territory drawn upon by them is much larger than was expected. The pumping of natural gas in order to utilize the entire supply is the most hopeful element in the outlook for a continued supply. It is this feature which made possible the use of a larger quantity of natural gas last year than the year before. The outlook is that natural gas will be utilized for as long a period as has already elapsed since the industry began, with the greater part to be furnished by the Mid-Continent field.

NATURE AND EXTENT OF WASTE IN THE EXTRACTION OF NATURAL GAS.

Waste of natural gas will be divided into three classes: First, waste incident to the discovery of a natural-gas field; second, waste in oil production; third, waste in consumption.

WASTE FROM HIGH-PRESSURE WELLS.

It has been a common experience in the discovery of a gas field to encounter pressures so great as to lead to great difficulty in capping, and thus confining the gas until needed. Noted instances of this were the Homewood well near Pittsburg, the Karg and Adams wells in Ohio, the Caney Fork well in Kansas, and, more recently, the wells of the Caddo field in northwestern Louisiana. Individual wells among these have wasted as much as 25,000,000 cubic feet per day, or sufficient gas to supply the entire consumption of three cities the size of Washington, D. C. In the Caddo field at the present time the waste of this character is estimated at 70,000,000 cubic feet per day. In this case wells are drilled through the gas-producing stratum in search of petroleum, which is usually found a few hundred feet below. The natural gas is cased off, but usually, owing to lack of skill on the part of the driller and indifference to the waste of gas, the gas escapes around the casing in increasing volume as the earth is loosened from around the pipe, and finally the force of the gas is sufficient to blow the casing entirely from the well. This has happened in four wells already in the Caddo field. When a well is thus "blown out" little effort has been made to close it. It has been the practice to set fire to the gas for an advertisement to the region.

WASTE OF GAS FROM OIL WELLS.

The production of more or less gas is incident to the drilling of all oil wells, and in most of them, by the time the petroleum-bearing sand is reached, the escape of gas is very great. Taken altogether, the waste of gas by this means is much greater and much more difficult to prevent than the waste from high-pressure gas wells.

In the first days of oil-well drilling in Pennsylvania, natural gas was a nuisance and a menace to the oil producer. This menace became greater with the volume of the gas. It developed a hostility toward natural gas on the part of the oil-well driller, which has increased rather than diminished up to the present time. It is to this hostility that the present waste of natural gas in oil regions is due. When natural gas was encountered in a sand above the expected oil stratum, it always cost considerable money to case it off and pack it in order to continue the drilling, and frequently caused explosions, tearing out the side of the well and occasionally blowing out the casing, causing the ruin of the enterprise. Every oil well now drilled includes in its outfit pipes connected with the casing for carrying the natural gas to a safe distance. Frequently it is burned to get rid of it, sometimes under the boiler to supply power for the well drilling and pumping. This practice has become so general that it is a common custom to pay $5 per twenty-four hours for the power for a well-pumping station. When the natural gas contains appreciable amounts of hydrogen sulphide, with the consequent injury to health, its presence is proportionately less welcome.

It is difficult for the oil-well driller to obtain a prompt and profitable market for the natural gas, whereas with oil it is only necessary to connect the well to a tank, and the cash for the product can be obtained within a few hours. Occasionally, when the pressure due to natural gas is greatly relieved, oil is found. The oil-well driller has accepted this exceptional case as a rule, and is apt to give all possible vent to the gas in the hope of its being followed by the desired petroleum. As to the amount of natural gas which is being wasted daily, no accurate statistics have been attempted, and the judgment of Dr. I. C. White,[a] state geologist of West Virginia, may well be accepted, to the effect that no less than 1,000,000,000 cubic feet of gas are wasted every twenty-four hours. Of this undoubtedly the larger part is wasted in the production of oil. Pumping the oil leaves the wells more or less open, and prevents any careful saving of the gas.

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[a] Conference on the conservation of natural resources, White House, "Waste of fuel resources," p. 5.

WASTE IN CONSUMPTION.

Directly associated with the waste of natural gas by allowing it to escape freely from oil and gas wells is the form of waste where the gas is used, by delivering it through pipes back into the ground in oil wells below the oil-bearing stratum, so that it will spray the oil to the surface. The mixture of oil and gas then runs into a tank where the oil is saved, but usually the gas is allowed free vent to the outside air. The lack of care in saving the gas after thus using it is a good example of the carelessness with this material prevalent in the oil fields.

Where natural gas is utilized for power, heat, and the lighting of dwellings and has once entered the pipe lines of the distributer, the waste is comparatively small, and little can be said at the present time in regard to any serious loss due to ineffective consumption. Much is used for lighting with incandescent mantles, an efficient use which leaves practically nothing to be desired. A still greater quantity is burned in stoves or in grates, under conditions which are also efficient. For power purposes there is little excuse for burning gas under boilers for the generation of steam, when so much greater economy can readily be produced by consuming it in internal-combustion engines, and the adoption of the gas engine in the place of steam should proceed with far greater rapidity than at present. The following table, prepared by Dr. F. H. Oliphant in 1892,[a] shows that nine-tenths of all the gas used could be saved by substituting internal-combustion engines for the kind of steam engines in use in the oil regions.

Comparison of fuel per indicated horsepower per hour for different types of engines.

Type of engine.	Cubic feet of gas.
Large natural-gas engine, highest type	9
Ordinary natural-gas engine	13
Triple-expansion condensing steam engine	16
Double-expansion condensing steam engine	20
Single-cylinder and cut-off steam engine	40
Ordinary high pressure, without cut-off, steam engine	80
Ordinary oil well pumping steam engine	130

METHODS OF PREVENTING OR LESSENING THE WASTE OF NATURAL GAS.

What has been said above concerning the substitution of gas engines supplied with natural gas, instead of burning natural gas under steam boilers, is a matter of small moment compared with the prevention of escape of natural gas into the air. Our total consumption of natural gas in the United States in 1907 was 404,000,000,000 cubic feet per year, whereas the amount wasted—not burned at all—was estimated at practically the same amount. Thus only half of all the natural gas actually produced goes to any useful purpose. This waste should furnish light for half the urban population of the United States. Remedy for this waste by legislation has been extremely effective in Indiana, Ohio, and Pennsylvania. Only a part of the credit for stopping natural-gas waste is due to legislation, much credit being due to the natural-gas companies themselves for taking the initiative in this reform and carrying it out with most commendable vigor. As a result, the waste of natural gas in these States has practically ceased. Great precautions are now used for the suppression of every flambeau or open gaslight. They are only to be seen at the present time occasionally in connection with the drilling of oil wells. These precautions in late years have not been due so much to legal restrictions as to the efforts of the natural-gas distributers to economize in every direction in the saving of natural gas. The laws of Pennsylvania, West Virginia, Ohio, and Indiana call for the efficient capping of every natural-gas well when not in use. This, however, does not prevent the escape of natural gas where it is an incident of oil production. In this field a more practical plan will depend on the cooperation of the natural-gas and oil-collecting companies, by which the oil producer may receive pay promptly for natural gas to be collected by the natural-gas companies from his oil well. In West Virginia the oil-collecting companies and the natural-gas collecting companies are usually simply branches of the same company, and this plan of collecting gas from the oil wells is already being carried into effect. The ingenuity and watchfulness of the natural-gas companies has effected far greater saving in natural gas than was believed possible five years ago. The result is in evidence from the gain in production in Pennsylvania and West Virginia, where high pressures have practically ceased.

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[a] Mineral Resources, 1892.

EXTENSION OF NATURAL-GAS SUPPLIES.

PREVENTION OF WASTE IN EXTRACTION AND IN USE.

It is of prime necessity that the laws concerning the capping of natural-gas wells, which have had such good effect in the principal oil and gas producing States, should be extended to the newer fields in the Southern and Southwestern States, and that the most radical measures should be taken to promptly suppress the great waste in these fields at the present time. When effective laws are in operation controlling the escape of gas from high-pressure wells, the problem will be reduced to saving the gas from the oil wells—a problem which can be solved only by affording a prompt and efficient market for the gas, even when produced in small quantity. Meantime, the problem of compressing natural gas in steel cylinders for small-scale transportation is receiving much consideration. Within the next few years success will undoubtedly be attained in returning the natural gas to reservoirs within the earth, which have proved to be sufficiently tight to hold the gas under heavy pressure. Experiments in this direction, costing more than $125,000, are being carried out in Ohio.

INCREASING EFFICIENCY IN USE.

This has already been sufficiently referred to in a previous paragraph.

DISCOVERY AND DEVELOPMENT OF SUBSTITUTES.

Unlike petroleum, natural gas can be replaced efficiently, at least for all practical purposes, by fuel gases produced by methods which are already well understood and are being studied with great care by the technologic branch of the United States Geological Survey. This substitution of fuel gas is well understood. The replacement of the artificial gas for the natural will regularly follow the trade relation of price. It is known that many large culm banks and other amounts of refuse coal are already owned by the natural-gas companies in anticipation of their utilization at the place where they occur, for making and distributing gas to distant points of consumption. This long-distance transportation of natural gas has been developed on so large a scale between West Virginia and Cleveland, Ohio, that the transmission of fuel gas over long distances is now also being studied as a certain feature of future industrial progress.

PEAT RESOURCES OF THE UNITED STATES EXCLUSIVE OF ALASKA.

By Charles A. Davis,
United States Geological Survey.

Peat as a source of fuel and power, as well as the raw material upon which may be based a number of industries, has but recently attracted general attention in this country. It has, however, long been used in northern Europe, where it is estimated that in the neighborhood of 10,000,000 tons prepared in various ways are consumed as fuel annually, and smaller amounts are used as stable litter, for sanitary purposes, and in various trades and arts.

It has been assumed by engineers, economists, economic geologists, and others, because of the abundance and cheapness of good coal and wood in the United States, that peat could not be used profitably in competition with them, at least for a long time to come.

Recent developments in the utilization of low-grade fuels in producer-gas engines, and the very considerable successful use of peat for the generation of fuel, illuminating and producer gas in Sweden, Germany, Russia, and other countries of Europe, have made a marked impression on those scientists and others in America who have followed the march of events in this direction. and these developments have aroused new interest in the possibility of using peat as an auxiliary fuel.

Already preliminary experiments have been made by the technologic branch of the United States Geological Survey with a large gas producer, which confirm the reports of foreign success in this direction, showing that some peats of American origin are little inferior to many grades of bituminous coal now on the market, and superior to some in the quantity of producer gas to be derived from them and in the calorific value of the gas.

Still more recent than this work is the report from Germany that by the investigations of Doctors Frank and Caro it is possible to recover a large part of the combined nitrogen contained in peat, while it is being converted to gas in the gas producer, as ammonium sulphate; and that where the nitrogen is present in amounts slightly above 1 per cent of the dry matter of the peat, the quantity of ammonium sulphate obtained pays the expenses of maintaining the plant, of gasifying the peat, and a profit besides, leaving the gas as an additional profit. As many American peats have more than 2 per cent of combined nitrogen and a considerable number of analyses show above 3 per cent, it is probable that in the near future peat beds will be profitably utilized for the production of power and ammonium salts in the United States.

This is the more likely when it is considered that the region of most abundant occurrence of peat in large deposits lies along the northern border of the country and in the eastern Coastal Plain. There are also smaller areas where it is found, as in the western mountains and in the moister portions of the Pacific slope. The States containing the greatest amount of peat are the eastern Dakotas, Minnesota, Wisconsin, Michigan, northern Iowa, Illinois, Indiana and Ohio, New York, the New England States, New Jersey, the coastal portions of Virginia, North and South Carolina, Georgia, and practically all of Florida. It is also assumed that there are workable peat beds in the swampy parts of the Gulf States and in those portions of the flood plain of the Mississippi remote from the stream.

It will be noted that these regions of frequent occurrence of peat are practically all outside of the coal fields, with the exception of Michigan, where, as is well known, the coal basin has not been found to be productive except in limited marginal areas, very small in comparison with that of the entire basin.

As a sign of the times it may be stated that work is about to begin in Florida on a plant for generating electric power by producer-gas engines using air-dried peat as fuel, the power to be transmitted to Jacksonville. Aside from other phases of the question it should be remembered that peat can be mined and prepared for the gas producer by the simplest and most inexpensive equipment, and with a minimum of danger, since all of the workings are open cuts made by the use of spades, or of ordinary excavating or dredging machinery, so that none of the dangers of underground mining are encountered.

On the other hand, the great drawback in the preparation of peat for fuel or other uses has always been and continues to be the fact that it contains from 85 to 90 per cent or more of water as it comes from the beds, and that the greater part of this water can not be pressed out but must be removed by evaporation. Peat which is air dry contains from 15 to 25 per cent of water, and its theoretical efficiency is lowered thereby in nearly direct proportion to the amount of water present.

In gas producers of recent types, however, it is reported that peat with 40 per cent water has been used with success, and for this purpose the question of excess of water has apparently been solved by plowing or digging up the peat and allowing it to dry out by exposure to the wind and sun on the surface from which it is taken. In Florida, even in midwinter, peat taken from below the water level, ground in a pug mill, and afterward spread over a drying ground in a layer 8 inches thick, dries to the air-dry state in about three weeks, and is ready for use in a gas producer in less time.

The question of artificially drying peat for fuel has received and is now engaging the attention of able engineers and inventors, and, in the opinion of many, the successful solution of this problem is necessary before any considerable increase in the use of peat for ordinary fuel can be expected.

Briefly stated, the matter rests upon the finding of a way to handle peat with about 90 per cent of water rapidly and cheaply enough so that the 250 pounds of salable material, which will result when it has reached the air-dry state, will pay the cost not only of the processes of preparation, but also of management, amortization, and selling, and return a profit on the original investment. Attention should be called to the fact that if peat with 90 per cent water has its moisture content reduced to 40 per cent, it loses more than half of its content of water, and that this amount is readily extracted by very simple and inexpensive processes.

In Europe, peat is prepared for fuel in several ways designed primarily to render it transportable and efficient as a source of energy. As cut peat it is used extensively for domestic purposes in the form of air-dried sods or blocks cut by hand with specially designed spades. A more compact and efficient fuel is made by more or less thoroughly macerating the peat and pressing it into molds, after which it is dried by spreading the blocks on the ground, exposed to sun or wind, or by grinding it in a specially constructed pug mill similar to that used in grinding clay for making bricks. The peat is ground wet as it comes from the beds, and delivered from the mill in the form of wet bricks, which on exposure to the air and sun's heat for some time become dry, firm, tough, and nonabsorbent. This is machine peat, which is rated the most generally successful form of peat fuel for domestic and boiler use on the markets of Europe. As marketed, this product contains from 20 to 25 per cent of moisture and has, theoretically, about 65 per cent of the fuel value of the same weight of good bituminous coal when burned in stoves or under boilers, but practically, because of the lack of waste of the peat, in the form of ash, smoke, clinker, and unconsumed portions, its real value is higher than is indicated by comparison of the possible heat units to be obtained.

As peat briquets the material is more compact, burns more slowly and persistently, and stands transportation and handling well. The peat is dried thoroughly, powdered, and briquetted, either without or with a binder or in mixture with coal or lignite.

An increasing amount of peat is manufactured into charcoal or peat coke, especially in Germany, where it is used somewhat extensively as a substitute for wood charcoal in smelting iron and in other metallurgical processes, including the refining of copper, steel making, etc. Of the processes so far developed for the manufacture of peat coke none have proved profitable on a commercial scale, except such as condense the distillates and recover a series of by-products similar to those obtained by the destructive distillation of wood, viz, fuel gases, methyl alcohol, acetic acid, lime acetate, ammonium salts, tar and its derivatives. This process involves large preliminary investment and the maintenance of costly plants, but where a good market can be found for the by-products this seems to be justified, according to unbiased and trustworthy reports from Europe. In preparation for coking, the peat is treated exactly as if it were to be sold as machine-pressed peat and is stored in open sheds until needed for the coking retorts.

An increasing amount of peat in the form of powder burned with blast burners is used abroad for firing under boilers and in brick and cement burning; where properly prepared and the firing rightly controlled it approaches theoretical efficiency when used in this way.

The production of gas from peat, as has been stated, has passed beyond the experimental stage, and peat gas is used for mettalurgical purposes, boiler firing, making lime and brick, and to some extent in making glass, while a rapidly growing number of producer-gas plants for using peat are being installed for generating electric power for transmission directly from the larger peat deposits to centers of use.

In view of all of these considerations the following estimates of the peat resources of the United States have been prepared with the view of at least directing attention to the very considerable source of wealth to the nation which is now lying entirely undeveloped in the swamps and bogs of the country. It will also be noted in considering the possibilities of the peat deposits that they furnish potential substitutes for wood in various departments of industry, and in some considerable degree in these directions may relieve the drain upon the vanishing forests.

In making the estimates given below it has been the aim of the writer to be conservative in every detail, and it is believed that in no case will they be found too optimistic.

The total swamp area of the United States, exclusive of Alaska, is estimated to be 139,855 square miles.[a] Of this 8 per cent is assumed to have peat beds of good quality, or 11,188 square miles. The peat in this area is assumed to average at least 9 feet in depth and to contain 200 tons of dry fuel per acre for each foot in depth, or a total of 12,888,500,000 tons. Its value, if converted into machine peat bricks at $3 per ton, would be $38,665,700,000. The value if coked and the by-products of distillation saved would be as follows:

Quantity and value of peat coke and by-products from peat deposits of the United States.

	Product in tons.	Value.
Peat coke	3,608,800,000	[a]$26,005,300,000
Illuminating oils	257,800,000	4,474,200,000
Lubricating oils	90,200,000	
Paraffin wax	38,700,000	3,479,900,000
Phenol	167,500,000	66,345,100,000
Asphalt	25,800,000	824,900,000
Wood alcohol	43,800,000	7,844,000,000
Acetic acid	56,700,000	2,268,800,000
Ammonium sulphate	39,900,000	2,777,400,000
Combustible gases	738,400,000	6,501,300,000

[a] Charcoal price. At coke price the value would be $9,024,200,000.

The better grades of peat coke are nearly free from sulphur and phosphorus, and may be used wherever hard-wood charcoal is required. The quantity of wood required to make charcoal equivalent to the amount of the peat coke given in the estimate would be approximately 8,019,800,000 cords. The uncondensable gas given off from the retorts while the peat is being converted to coke has good fuel value, the maximum being about 300 B. t. u. per cubic foot, and has been successfully used for heating the retorts and for other fuel purposes.

If converted into producer gas by the most recently developed processes, so that the combined nitrogen of the peat is converted into ammonia and fixed as ammonium sulphate, there would be possibly available 619,257,511,000,000 cubic feet of producer gas, with a calorific value of 145 B. t. u. per cubic foot. Assuming 1.5 per cent of nitrogen as an average content of the peat, which is low, since many analyses show more than 3 per cent, 100 pounds of ammonium sulphate to the ton of peat treated in the gas producer could be obtained.

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[a] Sixtieth Congress, first session, S. Doc. 151.

On this assumption there is stored up nitrogen enough in the peat to supply at least 644,400,000 tons of ammonium sulphate, having a value of $36,732,400,000, in addition to the gas produced.

Recent tests reported from Europe show that from 2 to 2.5 pounds of peat will produce an effective horsepower per hour, if reduced to gas in a properly designed gas producer and used in the gas engine. Taking the larger amount, to be conservative, it is evident that there is stored up in the peat beds of the country, as estimated above, energy sufficient to develop 10,310,860,800,000 effective horsepower hours.

In Europe great quantities of the more fibrous types of peat are manufactured into stable litter, for bedding live stock, and peat mull, or powder, for absorbent and sanitary uses. Of this class of material it is estimated that there are at least 2,578,000,000 tons available. This class of material is superior to straw and other substances now generally used for the purpose, and would readily bring $10 per ton, or the whole amount has a prospective value of $25,780,000,000. The only factory (located in Indiana) now making a product of this class in the United States sells its entire output of several hundred tons per annum at about $12 per ton.

A single plant for making paper from peat is in operation in Michigan. Possibly 5 per cent of the total amount of the peat of the country is suitable for this purpose, or 644,400,000 tons. The use of this material would reduce the consumption of wood for the purposes of making coarse papers and pasteboard, by whatever amount it displaced wood pulp in the manufacture of such materials.

In the United States peat is being somewhat extensively manufactured into fertilizer filler, material used in making various grades of artificial fertilizers in which slaughterhouse and other refuse animal matter rich in nitrogen are ingredients or in which hygroscopic mineral compounds are used. Peat in the form of dry powder is especially adapted to this use, since it absorbs water and ammonia readily, is a deodorizer, and to a considerable extent prevents fermentation and decomposition. At the prices now obtained for peat suitable for this purpose in the form of dry powder, and considering one-half of the total amount suitable for the purpose, its value is estimated to be $38,666,000,000, or about the same as the valuation of the whole for ordinary fuel.

Ethyl or "grain" alcohol has been made from the less thoroughly decomposed peats in Denmark and Sweden at a cost estimated at about 47 cents per gallon.

If 10 per cent of the entire body of peat in the country can be used in this way, about 70,900,000 tons of alcohol can be obtained from peat. It must be said in passing that this process is as yet hardly past the experimental phases.

Artificial wood, a fireproof or slow-burning composition of peat and mineral cements, has been made in Germany on a small scale for paving blocks and similar uses, as well as for larger structural purposes, as a substitute for wood or stone in buildings. About 10 per cent of the entire peat deposits of the United States may be suitable for this composition, or 1,288,800,000 tons, the use of which would release an equivalent amount of sawed lumber for other uses or to be held in reserve against future need.

Fibrous peat, properly cleansed of the finer material associated with it, is finding a constantly growing use in Europe as packing material for fragile or perishable articles, and for protecting and insulating water and other pipes subjected to the liability of freezing. The peat best adapted to this use is too light in weight and too loose in texture for fuel manufacture, and may be estimated to occur to the amount of 500,000,000 tons, with a market value of $3,000,000,000, displacing excelsior, hay, straw, paper, and other similar materials which are now used.

Fabrics of various qualities and kinds, mattresses for hospitals, and fiber for surgical and other asceptic dressings and as a substitute for silk in cloth weaving have been made from certain grades of peat, but the market is so well supplied with other products for the same purpose, which are of as good or better quality, that the use of the peat products has never reached any extensive commercial scale and does not seem likely to do so in the near future.

It is clearly apparent, however, that in the peat beds of the United States there lies undeveloped—even entirely untouched—a vast amount of raw material from which may be derived, by intelligent and conservative exploitation, fuel, power, fertilizing material, and the raw materials from which may be made a number of valuable products, all of which will serve to supplement other resources which are now known to be limited in quantity. By utilizing these resources also the wealth of the nation may be possibly increased by the not inconsiderable sums which represent the potential cash value of the peat beds and their products, and an equivalent amount of other material will be rendered free for other purposes.

ABSTRACT OF ESTIMATE OF THE PEAT RESOURCES OF THE UNITED STATES.

Peat, a fuel used in Europe to the amount of 10,000,000 tons per annum, is an almost unknown material in the United States, although possessing properties which make it an excellent domestic fuel and desirable for gas production on a large scale.

As the area of the peat beds in the United States, and the quantity of workable material which they contain, is almost unknown, the estimates submitted are but rough approximations. The following are sources of information used here: (1) Publications and topographic maps of the United States Geological Survey; (2) reports of the state geological surveys of New York, Michigan, Iowa, Indiana, Massachusetts, and New Jersey; (3) cooperative reconnaissance peat surveys undertaken by the United States Geological Survey and the state surveys of Connecticut, Maine, and Wisconsin; (4) personal observation of the writer in various parts of the country.

The total area of swamp land is estimated by the United States Geological Survey[a] to be 139,855 square miles. The writer estimates 8 per cent of this to have peat beds which would average 9 feet deep, or 11,188 square miles, with an average possible production of 200 tons of dry fuel per acre-foot, or a total of 12,888,500,000 tons.

The greater part of this material occurs in that part of the country without productive coal fields, in eastern North and South Dakota,

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[a] Sixtieth Congress, first session, S. Doc. 151.

Minnesota, Wisconsin, Michigan, New York, and the New England States, in northern Iowa, Illinois, Indiana, Ohio, in the coastal plain region, in eastern New Jersey, Virginia, North and South Carolina, Georgia, and the whole of Florida. The swamp areas of the Gulf States and of the flood plain of the Mississippi River, as well as those of the Pacific States, also contain workable peat beds, but in none of these is there any considerable overlapping of the peaty areas into workable coal fields.

It is estimated that, in the vicinity of the beds, this quantity of peat would have a value of $3 per ton in the form of air-dry blocks, or a total of $38,665,700,000, and that once established on a commercial basis the entire product would find ready sale as fast as produced. If this peat were all used in by-product gas producers, to this value as fuel may be added the value of 644,400,000 tons of ammonium sulphate, which at present prices would be worth $36,732,400,000.

Peat has been successfully used as a source of producer gas, of a form of charcoal or coke, of various by-products from the coke retorts similar to those obtained from wood distillation, of fuel and illuminating gas, of fertilizer filler, and of paper, litter for stables, and packing materials. In these forms the prospective value of the total peat of the country is much larger than as peat fuel.

IRON ORES OF THE UNITED STATES.

By C. W. Hayes,
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INTRODUCTION.

No previous inventory of the iron-ore supplies of the United States in any detail has ever been published, and the present one must be considered only a first approximation which will be materially modified as new quantitative data are made available by future public and private investigations. The estimates of ore supplies given in this paper are not based upon the judgment of any individual, but so far as possible represent the consensus of opinion of those best qualified to form an opinion. Cordial cooperation in making up the estimates has been given by officers of private corporations and the several state geological surveys and by economic geologists and mining engineers generally. Special acknowledgments are due to Messrs. W. N. Merriam, C. K. Leith, D. H. Newland, H. M. Beuhler, W. S. Bayley, T. L. Watson, R. C. Hills, and J. F. Kemp, who have furnished information which could not have been obtained from any other source.

CHEMICAL CLASSIFICATION.

The commercial ores of iron, on the basis of chemical composition, fall into two main classes, i. e., oxides and carbonates. The latter class is relatively unimportant, furnishing in the United States less than one-twentieth of 1 per cent of the annual production. The oxides are further separated, according to the proportion of oxygen and combined water which they contain, into three classes. The chemical and commercial classification is therefore as follows:

1. *Magnetite.*—Magnetic oxide, Fe_3O_4, including titaniferous magnetite. Theoretical iron content, 72.4 per cent. Generally containing some hematite.
2. *Hematite.*—Anhydrous sesquioxide, Fe_2O_3, including specular and red hematite, red fossil ore, oolitic ore, etc. Theoretical iron content, 70 per cent.
3. *Brown ore.*—Hydrous sesquioxide, $Fe_2O_3nH_2O$, including turgite, limonite, goethite, or a mixture of these minerals, known locally as brown hematite, bog ore, etc. Theoretical iron content, 59.8–66.2 per cent.
4. *Carbonate.*—Siderite, iron carbonate, $FeCO_3$, known locally as spathic ore, black band ore, kidney ore, etc. Theoretical iron content, 48.2 per cent.

GEOLOGIC CLASSIFICATION.

In their geologic relations and mode of occurrence the iron ores may be further classified as follows:

1. *Magmatic segregations in basic igneous rocks.*—The titaniferous magnetites of the Adirondack region represent this type. A characteristic of such deposits is the perfect gradation from the ore into the surrounding rock by an increase in the gangue, which consists of the same minerals as the associated igneous rock. The deposits are of great size and present large possibilities of utilization by concentration or with modification of furnace practice which will permit their economical reduction.

2. *Contact deposits, formed in connection with the intrusion of igneous rocks at their contact with the intruded sediments, generally limestones.*—These appear to be due to ascending heated waters and vapors given off by the cooling igneous rock. The ores include both magnetite and hematite. Typical examples are the Cornwall deposits of Pennsylvania and many of the western iron-ore deposits, as those at Hanover, N. Mex., and Iron Springs, Utah.

3. *Concentration deposits.*—These include all forms of the oxide ores in which the iron, originally disseminated through the rocks, has been dissolved, transferred, and redeposited by circulating waters. It includes most of the brown ores of the Appalachian region in which the iron was originally disseminated through a great mass of limestones and shales and has been leached out and concentrated by surface waters during the erosion of these rocks. In some cases the iron was probably deposited as carbonate or sulphide and subsequently changed in place to hydrous oxide. It includes the bog-ore deposits, which have been formed or are now forming in swamps, to which iron is brought in soluble form as organic compounds and precipitated by the breaking up of those compounds through oxidation.

4. *Replacement deposits.*—These are closely related to the concentration deposits, the principal difference being that the ore-bearing solution has derived the iron from an outside source and deposited it in place of some definite portion of an original rock series, generally a limestone. They include all classes of ores, both oxides and carbonates, their composition depending on the conditions of deposition and the subsequent alterations which they have undergone. An example of this type is the so-called Oriskany ore of Virginia. In this case the iron derived from a great mass of overlying shales has been carried in solution, and where structural conditions were favorable deposited in place of a certain easily soluble bed of limestone for a variable distance from its outcrop.

5. *Bedded deposits.*—These include all deposits in which the ore forms tabular or lenticular bodies which lie parallel to the bedding or foliation of the inclosing rocks. Their origin may be diverse, but their common characteristic is great lateral extent compared with thickness. In many bedded deposits, though not in all of them, the ore is sharply differentiated from the surrounding rocks. Magnetite deposits of this type are the Adirondack ores associated with metamorphic sediments and with gneisses of uncertain origin. Of the hematite deposits of this type are the enormous deposits of the Lake Superior district, where certain beds of the iron formation have been enriched both by the removal of silica in solution and by the depo-

sition of additional iron. It also includes the gray specular ores of Alabama, which are associated with Cambrian and pre-Cambrian slates and sandstones, and the important red ores, fossil and oolitic, which form regular sedimentary beds, differing only in composition from associated Silurian sandstones and shales. Of the carbonates it includes the black-band ores, which occur as layers of nodules or continuous beds associated with the "Coal Measures" in Ohio and Pennsylvania.

6. *Gossan deposits.*—Iron sulphides tend to oxidize with loss of sulphur when exposed to surface weathering, and deposits of pyrite and pyrrhotite are therefore generally covered with a deposit of residual brown ore, which extends down to the level of permanent ground water. Examples of this type are the brown ore on the outcrop of the pyrrhotite veins at Ducktown, Tenn., and the iron-ore capping of many metalliferous veins in the West.

Referred to the ultimate source of the material, it may be stated in general that the iron ores are derived from the iron minerals either segregated or disseminated in igneous rocks or the iron minerals deposited by igneous emanations, which have been worked over in varying degrees by the agents of weathering and sedimentary and chemical deposition at the surface of the earth. Iron compounds are among the most stable substances under surface conditions, and hence the net result of the changes at the earth's surface is to concentrate iron minerals mechanically and chemically as compared with associated minerals.

VALUE OF ESTIMATES.

An understanding of the above chemical and geologic classifications of iron ores is essential for an appreciation of the limitations and uncertainties of any estimate of the ore supplies of the country. It will be readily understood that with the great diversity in type of deposits there must be a very wide difference in the degree of accuracy with which the ore can be estimated. The closest approximation can be made in case of bedded deposits such as the Clinton red hematites. These beds vary in thickness and composition from place to place, but the variations are similar to those characterizing other sedimentary beds such as coal, and with a minimum amount of testing on the outcrop and at depth their contents can be calculated with a fair degree of certainty. Certain assumptions, however, must always be made. Thus it is assumed that observed variations in composition and thickness continue with regularity between and beyond points of observations; also that a certain depth will limit workability. This limiting depth will depend upon a variety of conditions which can not be determined in advance of mining, and hence the depth fixed upon in making calculations will be largely a matter of opinion, and must be expected to change with changing commercial conditions. Hence it is doubtful if even the best known and most thoroughly tested deposits of red hematite can be estimated within 10 per cent of their actual yield. At the other extreme are the concentration deposits of brown ore. These are extremely variable both in depth and horizontal extent. Surface indications are thoroughly unreliable, and those most experienced in working such deposits are practically unanimous in the opinion that no deposit can be safely estimated until every ton of ore has been mined. Under such circumstances the estimates given below of ore remaining in this class of deposits can only be regarded as having a degree of accuracy represented by a factor varying between 0.7 and 3.

Intermediate between these extremes are the most important deposits, including those of the Lake Superior and Adirondack districts. The former by reason of their greater regularity and the thoroughness with which they have been tested may be considered as known within 15 or 20 per cent. The latter are much less fully tested, and estimates of their probable yield are based upon assumptions which further development may prove to be erroneous. Estimates of the western ore deposits vary in value because of inherent uncertainties due to the nature of the deposits and to the very unequal information concerning different districts.

AVAILABILITY.

Any estimate of the iron-ore supplies of the United States must separate the ores into two classes on the basis of availability. This separation is difficult, and opinions vary widely as to where the line should be drawn. Evidently the question is one of costs: (*a*) The cost of the ore delivered at the furnace and (*b*) the cost of reduction. Actual production, past and present, being determined by the interaction of various factors, affords the best criteria of availability.

The two factors which enter most directly into the cost of ore at the furnace are accessibility and mining conditions. Many iron-ore deposits are known in regions so remote from fuel supply and from transportation lines that they may be considered unavailable at present or so long as they are compelled to compete with more accessible ores. At the same time they must be taken into account in considering the total reserves, for accessibility is only relative and no deposit, if sufficiently large to warrant the expenditure necessary for constructing roads, can be regarded as permanently inaccessible. Distance from fuel is, of course, a more serious drawback than absence of present means of transportation, while those supplied with water transportation will bear a longer haul than those carried entirely by rail.

Mining conditions may be such as to make the cost of raising the ore prohibitive at present. Such conditions are limiting depths beyond which mining, on account of the amount of water, may become very expensive, or thinness of the beds which necessitates a large amount of dead work. These conditions apply particularly to the Clinton ores and explain the difference between the total amount proved in these deposits and the amount considered at present available. Many deposits of brown ore can be worked cheaply in open pits for a certain distance from the surface, while the cost of stripping or of timbering to hold back the inclosing clay prevents their working to greater depths.

Another kind of limiting conditions arises from the fact that in many cases the ore is mixed with foreign material from which it must be separated. Thus many of the brown ores consist of small concretions scattered through clay, and a large amount of material must be passed through the washer to obtain the ore in suitable condition for the furnace. The ratio of ore to clay in deposits now being worked varies from 1:5 down to 1:20. When conditions permit the lowering of this ratio still further, large quantities of ore will be available in material which can not now be worked at a profit. Similar conditions control the availability of many of the magnetic deposits, except that here the objectionable elements are other minerals that are closely associated with the iron and must be separated by magnetic methods. The concentrated material is a high-grade ore, and the ratio of available to nonavailable in these deposits depends wholly upon cost of the process of concentration which they will bear in competition with other ores.

The second consideration affecting availability is the character of the ore itself. The content of metallic iron in ores used at present varies from 30 to 65 per cent. This wide variation is due in part to the nature of the other elements in the ore and in part to advantageous location. Thus the Clinton ores, containing as low as 30 per cent iron, can be used with advantage, because the lime which they contain makes them practically self-fluxing. At the same time they must be used near the point of production, since the low content of iron will not permit long transportation in competition with richer ores. On the other hand, siliceous ores containing less than 40 per cent iron are not considered at present available unless their location near the fuel is exceptionally favorable, since the cost of transportation per unit of iron is excessive and since a large amount of fuel is required to remove the silica. But there are enormous quantities of siliceous ore carrying from 35 to 40 per cent iron, particularly in the Lake Superior district, and this must be taken into account as a future reserve, though not at present available.

In the case of the titaniferous magnetites the ratio between the available and not available is difficult to determine. While these ores have been used only to a limited extent because of the difficulties attending the fluxing of the titanium, it seems probable that these difficulties will be overcome and a much larger use made of them either by employing a special flux in the furnace or by reducing the percentage of titanium in the charge by concentration or mixing with nontitaniferous ores.

The percentage of other constituents, such as phosphorus, sulphur, copper, chromium, manganese, and alumina, will determine the method and cost of reduction and the quality of the resulting iron. Hence these constituents, some of which are highly deleterious, may determine the question of availability by limiting the conditions under which the ore can be reduced or the product used.

Another factor is the nature of ownership. Where a large corporation controls a variety of ores and is equipped to assemble them and form any desired mixture or grade, ores may be used with advantage which would not be available if held by a smaller company not in a position to control the situation in a large way or compelled to dispose of a single kind of ore in the open market.

Because of the varying importance of these factors, future availability will obviously vary in a corresponding degree and the advantage which one district now possesses may pass to another. As the higher-grade ores of the Lake Superior region become depleted the lower-grade ores will be called upon with consequent increase in cost of transportation and smelting. The low-grade ores of the southeastern district, at present competing with the high-grade Lake Superior ores, will then have a decided advantage because of proximity to fuel supply.

The notable present tendency in the iron industry is the lower average iron content in the ores used. This tendency will undoubtedly continue in the future as the more easily accessible portions of the richer deposits are worked out. As a corollary to this is the observed tendency toward a decentralization of the iron industry, and with a decrease in the iron content of the ore used, involving a corresponding increase in cost of transportation per unit of iron, there will be an increase in the proportion of fuel which goes to the region producing the ore. This will be accompanied by the general adoption of by-product coking. It is an instructive fact that in certain furnaces now operating in the Lake Superior district the profit corresponds approximately to the value of the by-products from the coke ovens.

In making estimates all of these considerations, together with the best forecast that can be made of conditions as they will exist in the next ten years, have been taken into account in determining the ratio between available and nonavailable supplies.

GEOGRAPHIC AND GEOLOGIC DISTRIBUTION.

Iron being one of the most abundant elements, fourth in order of abundance, its natural compounds are found in practically all rocks and soils. To constitute an ore, however, certain of these minerals must be segregated into deposits of sufficient size and purity to permit economical working. Such deposits, considering the entire area of the country, are relatively infrequent. Iron ore is at present produced in only 29 of the 47 States and Territories, and about 79 per cent of the production (1907) was from two States—Minnesota and Michigan. It is evident that the distribution of the deposits is extremely uneven.

For convenience of description of the ores and discussion of the estimates the known ore deposits will be taken up by groups based on distribution and kind. A few deposits are not included in any of these groups, but the total tonnage of ore which they contain is so small as to be negligible in an estimate of the total for the entire country. The groups of deposits to be considered are the following: (1) Lake Superior ores; (2) Adirondack ores; (3) Clinton ores; (4) Appalachian metamorphic ores; (5) Appalachian brown ores; (6) Appalachian carbonate ores; (7) West Tennessee brown ores; (8) East Texas brown ores; (9) Ozark ores; (10) Rocky Mountain metamorphic ores; (11) Igneous contact ores.

(1) LAKE SUPERIOR ORES.

[Based on information furnished chiefly by C. K. Leith.]

GEOLOGIC RELATIONS.

The Lake Superior ores, chiefly hematites with subordinate amounts of magnetite, constitute approximately 80 per cent of the annual iron-ore production of the country. The total production from the region from its opening to the close of 1907 has come from the ancient folded and metamorphosed pre-Cambrian formations in Michigan, Minnesota, and Wisconsin in proportions shown in the following table:

Geologic sources of Lake Superior iron ores.

State.	District.	Geologic horizon.		
		Keewatin.	Middle Huronian.	Upper Huronian.
		Per cent.	*Per cent.*	*Per cent.*
Minnesota (46.555 per cent)	Mesabi			39.45
	Vermilion	7.105		
Michigan (50 per cent)	Gogebic			12.24
	Marquette		21.90	.50
	Menominee, including Crystal Falls, Iron River, etc.			15.36
Wisconsin (3.308 per cent)	Penokee			1.98
	Menominee (Florence)			1.26
	Baraboo			.068

The iron formations are sedimentary deposits, usually interbedded with slate, quartzite, dolomite, and sometimes with basic extrusives. They consisted originally of chert, containing beds of iron carbonate or of dark-green ferrous silicate granules, called greenalite. As a result of surface oxidation of the iron carbonate and greenalite, the great bulk of the formation within the zone of observation now consists of chert minutely interbedded with limonite or hematite, giving a banded rock variously called ferruginous chert, taconite, or jasper. The average proportion of iron in these siliceous rocks is between 25 and 37 per cent. Numerous slate layers form subordinate proportions of the iron formation.

The iron ores constitute concentrations of ore in the exposed parts of the iron formation, accomplished mainly by taking out the associated silica and leaving the iron in larger percentage, but also partly by solution, transportation, and redeposition of the iron when it is still in its soluble ferrous condition. The agents of alteration are surface waters carrying oxygen and carbon dioxide. The accessibility to the iron formation of these agents therefore determines the location, shape, and size of the ore deposits. The most favorable condition of accessibility is given by wide area of exposure of the iron formation, which is in turn a function of the dip. The flat-lying formation in the Mesabi Range exposes a greater surface to concentrating agents than the steeply dipping formation of similar thickness and character in the Gogebic range, with the result that the proportion altered to ore is much greater in the Mesabi district. A comparison of the actual areas of the different iron formations with their total shipments to date, and with their probable reserves, shows a very close relation between area and amount of ore developed. Also determining accessibility of the concentrating agents to the iron formation are numerous structural conditions, such as joints or faults or impervious pitching basements, favorable to rapid circulation of water. Finally, the texture of the iron formation itself, whether dense or porous, may determine the activity of the circulation of the waters.

It is therefore apparent that the size, shape, depth, and structural relations of the Lake Superior ores are in widest variety. In the flat-lying formations of the Mesabi Range the ore bodies have wide lateral extent as compared with depth, extremely irregular outlines partly controlled by jointing, abut irregularly on bottom and sides against unaltered portions of the iron formation, and when the glacial overburden is removed, are accessible to surface operations with steam shovels. In steeply dipping beds they have greater vertical as compared with horizontal dimensions, usually abut not only against unaltered parts of the iron formation, but against well-defined impervious walls consisting of slate, quartzite, dolomite, or bosses or dikes of greenstone, and in such beds underground mining is necessary. The maximum depth to which mining has extended is a little over 2,000 feet; the maximum horizontal extent thus far worked in a single mine is less than a mile, but deposits are known to connect for nearly 10 miles. An adequate summary of the variety of structural features of the several districts can not be made within the limits of this paper.

CHARACTER OF THE ORES.

The hematites and limonites making up the great bulk of the Lake Superior ores range in texture from soft and powdery to hard and crystalline. Both kinds usually have large pore space, due to the removal of silica by leaching. Locally, however, where the ores have been buried deeply in the zone of rock flowage, they have become dense, schistose, specular hematites and magnetites lacking pore space. Where the iron formation has been intruded by large masses of igneous rocks the ores are magnetic. The ores range in grade from above 60 per cent in iron down to 25 per cent in the lean parts of the iron formation. The average shipment for 1906 for the entire region was 59.8 per cent in iron. The difference between the iron ore and the iron formation is simply in the proportion of silica present.

The ores mined in the Lake Superior region to date have generally run above 50 per cent in iron. The lowest grade shipped has been about 40 per cent, in the case of local ores in demand for mixtures and favored by cheap mining and transportation. In mining much material running 40 per cent or even less is taken out and mixed with higher-grade ores to give a medium grade. Such low-grade material therefore does not figure obviously in the production. The percentage of iron in the ore mined from the region has fallen slowly but steadily in recent years, but the major part of the shipment is likely to remain above 50 per cent for some years to some. In the present estimate of available ores about 50 per cent of metallic iron has been taken as the minimum. It is fully appreciated that ores below this grade are even now locally available and will soon be used in larger quantities, but such ores as a whole must be considered still as belonging to the future supply. The ore supply of the Lake Superior district available under present conditions is therefore taken to include all ore above 55 per cent iron, estimated at 2,500,000,000 tons, and 25 per cent of all ore containing between 45 and 55 per cent iron, giving a total of 3,500,000,000 tons exclusive of the Clinton ores.

ESTIMATES OF LOW-GRADE ORES.

Difficulties beset estimates of the tonnage of low-grade ores available for the future. The lower limit of such grade must be chosen somewhat arbitrarily, and when it is chosen there is lack of sufficient analyses of the iron formation as a whole to separate the tonnage above the given grade. The mixing of high-grade and low-grade ores also complicates the situation. Extensive drilling operations have been directed mainly to determine the percentage of ore above 50 per cent and little attention has been given to the grading of ores running below this percentage. The averages of all available analyses from portions of the formation outside of the ore at present available, made by the mining companies of the Lake Superior district, give the following results:

Character of the iron-bearing formations of the Lake Superior district.

DIAMOND-DRILL CORES.

State.	Holes.	Average iron content.	Analyses.	Total footage.
		Per cent.		
Michigan	77	36.52	3,897	22,202
Minnesota	24	38.00	1,094	5,400
Wisconsin	30	36.40	1,517	4,814

OTHER SOURCES.

State.	Holes.	Average iron content.	Analyses.	Total footage.
Michigan:				
Trenches	....	41.53	94	975
Levels	....	38.40	905	[a]7,500

[a] Approximate.

It seems entirely probable, in view of the fact that 40 per cent ore is even now locally in demand, that the depletion of the higher-grade reserves may in time require the use of 35 per cent ore. If so, the tonnage is enormous. Planimeter measurements of areas of the iron formation, multiplied by the depths quite within the limits of actual mining at the present time, give the following results:

Tonnage of iron formations.

District.	Area.	Depth.	Volume.	Quantity.
Michigan:	*Sq. miles.*	*Feet.*	*Cu miles.*	*Tons.*
Crystal Falls	7.80	1,250	1.950	19,500,000,000
Marquette	28.50	1,250	7.100	71,000,000,000
Menominee	5.60	1,250	1.400	14,000,000,000
Penokee	11.60	1,250	2,900	29,000,000,000
Swanzy	1.00	1,000	.200	2,000,000,000
Minnesota:				
Mesabi	127.00	400	10.000	100,000,000,000
Vermilion	15.60	1,250	3.900	39,000,000,000
Wisconsin:				
Florence	.70	1,250	.175	1,750,000,000
	197.80	....	27.625	276,250,000,000
Ontario, Canada:				
Animikie	10.80	100	.20	2,000,000,000
Michipicoten	6.64	1,250	1.66	16,600,000,000
Other districts on north shore of Lake Superior	30.00	1,250	7.50	75,000,000,000
	47.44	....	9.36	93,600,000,000
Total	245.24	....	36.985	369,850,000,000

It is not proved, however, that this enormous tonnage will average as high in iron as these figures from the mining companies would indicate. Indeed, many parts of the formations are known to run lower than this. It is regarded safer, therefore, to use a smaller figure for the tonnage of ore running 35 per cent and over. Just what fraction of the total tonnage of the iron formations should be taken is a matter of more or less arbitrary choice. It is here put at 72,000,000,000 tons, divided as shown in the following table:

Estimates of Lake Superior ores.

District.	Available.	Not available.
Michigan:	*Long tons.*	*Long tons.*
Marquette district	110,000,000	15,900,000,000
Gogebic district	95,000,000	3,900,000,000
Menominee, Crystal Falls, and other districts	80,000,000	7,360,000,000
Minnesota:		
Mesabi district	3,100,000,000	39,000,000,000
Vermilion district	60,000,000	1,005,000,000
Cayuna and other districts	15,000,000	310,000,000
Wisconsin	40,000,000	4,525,000,000
Total	3,500,000,000	72,000,000,000

(2) ADIRONDACK ORES.

[Based on reports of the New York State Survey.]

The area of crystalline rocks forming the Adirondack district occupies the greater part of the State of New York north of the Mohawk Valley. The district contains a variety of iron ores differing in their character and geologic surroundings. Those found in sufficient abundance to be commercially important are nontitaniferous magnetites, titaniferous magnetites, and red hematites. Some deposits of limonite also occur as bog ores, but they are not generally of sufficient size to be considered an available source of ore at the present time.

The rocks of the Adirondack district, with the exception of small patches of Paleozoic sediments, are entirely pre-Cambrian, and are either wholly crystalline or highly metamorphosed. They are provisionally classed in three groups: (1) Sedimentary rocks, marble, schist, and gneiss; (2) gneisses of undetermined origin, but probably in part, at least, sedimentary; and (3) igneous plutonic rocks, anorthosite, gabbro, syenite, and granite. The first group occupies a relatively small part of the area, but with its various members are associated all of the hematite deposits and many of the nontitaniferous magnetites.

NONTITANIFEROUS MAGNETITES.

These are the most widespread of the Adirondack deposits, but the more important ones occur in two groups on the eastern border of the district in the Lake Champlain basin and in the western part of the district in St. Lawrence County. In the first group are the well-known Hammondville, Mineville, and Lyon Mountain deposits, and in the second the Benson, Jayville, Fine, and Clinton deposits.

The ores show great variation in their mineral and chemical composition, ranging from lean varieties, which consist of magnetite intermixed with the constituents of the wall rock, to those made up of practically pure magnetite. The richest, obtained principally from the Mineville group, average from 60 to 65 per cent iron, and considerable quantities have been obtained which approached the theoretical iron content of magnetite (72.4 per cent). The deposits carrying less than 50 per cent iron are generally considered too refractory for direct smelting and their utilization depends upon concentration. Large bodies of such ore occur in the Lyon Mountain, Arnold Hill, and St. Lawrence County deposits. The lowest grade of ore now worked carries about 35 per cent iron ore before concentration.

Both Bessemer and non-Bessemer ores occur, in some cases in adjoining deposits, though generally the ores from all deposits of a group show a fair degree of uniformity in respect to phosphorus content. The leaner ores are apt to be lowest in phosphorus, and concentrates produced at Lyon Mountain contain less than 0.01 per cent of that element with 65 per cent iron. The ores also carry a variable proportion of sulphur due to the admixture of pyrite and more rarely pyrrhotite.

The deposits occur in a variety of forms such as are common to the magnetites found in gneisses and schists elsewhere. In general they have a lenticular bedded form and are parallel to the foliation of the inclosing rocks. They partake of the same structural folds and faults as these rocks, and must therefore have been deposited before the regional compression occurred to which these structural features are due. While there has been much diversity of opinion regarding the origin of these ores, the view generally held at present is that they were introduced by processes connected with the intrusion of the igneous rocks.

The Adirondack magnetites were mined as early as the latter part of the eighteenth century and supplied many bloomeries and forges and, later, small charcoal furnaces. These have now all disappeared, and the ores are mostly shipped to the iron-making centers for smelting. There are, however, two coke furnaces in the region that are supplied by local mines. The total production up to the present time has been somewhat over 36,000,000 tons. Both open-cut and underground mining methods are employed, but chiefly the latter because of the high inclination of the ore bodies. A depth of 1,500 feet has been reached in the workings at Lyon Mountain, and about 2,000 feet at Barton Hill. Practically all of the ore is concentrated by the magnetic process, which yields concentrates containing from 60 to 65 per cent iron and at the same time effects a partial elimination of the phosphorus and sulphur. In fact, the treatment of the richer ores is designed primarily to reduce the phosphorus, and the concentration is a subordinate object.

While a few of these deposits have been drilled with sufficient thoroughness to permit a fairly definite estimate of their contents, this is not generally the case, and in most cases even the extent of the outcrop is not accurately known. Lines of magnetic attraction indicate the presence of ore bodies concerning which little else is known, and finally large areas in the Adirondack Mountains, heavily forested and drift covered, have not been examined in sufficient detail to determine whether or not they contain iron-ore deposits.

For these reasons it is impossible accurately to determine the ore reserves. It is estimated that the known deposits of high-grade ore will yield 35,000,000 tons, and that the leaner deposits, carrying over 35 per cent iron, will yield 75,000,000 tons of concentrates. The estimate of ore which is not now available because of great depth, or low grade, but which may be used eventually, is even more uncertain, but may be placed conservatively at 25,000,000 tons.

TITANIFEROUS MAGNETITES.

Under this class are included the ores which carry titanium as an essential ingredient. In general it amounts to at least 8 per cent of titanic acid (TiO_2), while the average is perhaps 15 per cent. These deposits occur within the margins of the gabbro-anorthosite area, chiefly in Essex and Franklin counties. In their relations to the inclosing rocks these deposits are sharply differentiated from the nontitaniferous magnetites which occur in the sedimentary and eruptive gneisses and schists. The titaniferous ores are believed to be the product of magmatic segregation, and hence intimately connected in origin with associated igneous rocks. The form of the ore bodies has not been accurately determined except in the case of a few of the smaller ones. The large bodies have nowhere been uncovered or sufficiently explored to afford an idea of their precise outlines. The richest ores contain little else than magnetite and ilmenite, and yield fully 60 per cent iron. From such pure aggregates there may be traced a continuous series of gradations by the entering of gangue minerals in increasingly greater proportion to the limiting wall rocks which hold only subordinate amounts of magnetite and ilmenite. The two minerals are often distinct in their crystallization, and show no tendency toward mutual intergrowth.

The use of ores containing high percentages of titanium is generally regarded as impracticable under present furnace practice because of the infusibility of the slags. They have, however, been smelted on a small scale in the Adirondacks, as well as in England and Sweden, and experiments have shown the feasibility of securing a fusible slag by properly proportioning the fluxes. A more promising solution of the problem is found in a reduction of the amount of titanium entering the furnace, both by concentration and by employing these ores as mixtures with nontitaniferous ores. Since the ilmenite is only feebly magnetic, it has been found practicable, at least on an experimental scale, to reduce the titanic oxide from 15 to 8 or 9 per cent by moderately fine crushing and magnetic concentration.

These deposits have been explored only far enough to prove that they contain a very large amount of ore which simply awaits the development of methods for overcoming the metallurgical difficulties due to the presence of the titanium. Assuming that these difficulties will be overcome, it is estimated that the known deposits in the Lake Sanford district alone contain at least 90,000,000 tons sufficiently accessible and high in grade to be now available, and that they may contain in addition 100,000,000 tons, which are not now but will be eventually available as an ore supply.

RED HEMATITES.

Hematite deposits of workable dimensions occur on the northwestern side of the Adirondacks in Jefferson and St. Lawrence counties. They are associated with the folded pre-Cambrian sedimentary (Grenville) series of schists, limestones, and gneisses, which attain greater areal development in that section than elsewhere in the Adirondack region. The ores are mainly soft, red hematites, with subordinate specular, and occupy zones of replacement along the contact of crystalline limestone and schist, and at times in the schist itself, with often a capping of Potsdam sandstone. A peculiar feature is the presence of a greenish mineral—locally called serpentine, but of chloritic nature—which seems to be an alteration product formed by reaction of the iron-bearing solutions upon the feldspathic schists and the occasional granitic intrusions of the walls. The source of the iron may be traced with some certainty to bands of pyrite and magnetite, which abound in the schists and which are subject to rapid weathering and to solution by ground waters. The principal mines have been opened along a narrow belt extending northeast from Antwerp nearly to the village of Gouverneur, but there are a number of outlying deposits that have been worked in former days for the supply of local furnaces. Mining was begun about 1835. Altogether the district has furnished probably 2,500,000 tons of non-Bessemer ore ranging from 45 to 60 per cent iron. The largest mines are the Dickson and Old Sterling near Antwerp and the Caledonia and Spragueville. Of recent years the output has been shipped to New Jersey and Pennsylvania for reduction.

Aside from the actual mine workings the district is practically unexplored, and it is impossible to draw any accurate conclusions as to the quantity of ore that may exist. Judging from the ore bodies developed in the mines recently operative, it seems safe, however, to place the resources at present available at 2,000,000 tons, while an equal quantity may be represented by other deposits that are not now workable by reason of their inaccessibility or other unfavorable circumstances.

Estimates of Adirondack ores.

	Available.	Not available.
	Long tons.	*Long tons.*
Nontitaniferous magnetites:		
High-grade ores	35,000,000	....
Concentrating ores (concentrates)	75,000,000	25,000,000
Titaniferous magnetites	90,000,000	100,000,000
Red hematites	2,000,000	2,000,000

(3) CLINTON ORES.

CHARACTER OF THE ORE.

The Clinton iron ore, so named from its typical occurrence at Clinton, N. Y., is an amorphous red hematite mixed with calcium carbonate, silica, aluminum silicate, and other minerals in minor quantities. It includes the varieties known as fossil ore and oolitic ore.

It occurs in lenticular beds analogous to the strata of sandstone, shale, and limestone, with which they are interbedded.

The fossil ore consists of aggregates of fossil organic remains in which the original calcium carbonate has been replaced partly or wholly by ferric oxide. The fossils, which consist of broken and waterworn fragments, were evidently gathered into beds by the action of waves and currents, and subsequently cemented together by calcium carbonate and ferric oxide. More or less clay material was also included in the beds during their deposition, and this now forms thin seams of shale.

The oolitic ore consists of aggregates of flat grains with rounded edges about the size and shape of flaxseeds. These grains generally lie parallel to the bedding planes of the rock, and the mass is cemented by ferric oxide and more or less calcium carbonate. The flattened grains have a nucleus of quartz, generally very minute, about which successive layers of iron oxide, and, in many instances, thin layers of amorphous silica and aluminous material, have been deposited. One of the two varieties of ore generally predominates in a bed, but in certain localities both fossil and oolitic materials are mixed in nearly equal proportions. The fossil ore, where unweathered, as compared with the oolitic ore in the same condition, is apt to be the more calcareous, while the oolitic ore may carry higher proportions of silica and alumina.

A characteristic of the Clinton ore is that where it has been weathered or acted upon by surface waters the lime carbonate is dissolved out, thereby increasing the content of iron oxide, silica, and other constituents proportionately. Such altered ore is termed "soft ore," and it is usually porous and friable as compared with the unaltered material, which is termed "hard ore." The alteration of the ore beds takes place at the outcrop and extends to varying depths from a few inches to 400 feet, depending on the attitude of the beds and on the thickness and permeability of the overlying rocks. The quantity of the soft ore is relatively small in comparison with the hard ore, and owing to its higher content of iron and its greater accessibility, a large part of the soft ore has already been mined.

In general the hard and semihard ores range in percentages of major constituents as follows: Metallic iron, 30 to 45 per cent; lime, 5 to 20 per cent; silica, 2 to 25 per cent; alumina, 2 to 5 per cent; magnesia, 1 to 3 per cent; phosphorus, 0.25 to 1.5 per cent; sulphur, a trace to 0.5 per cent; and water, 0.5 to 3 per cent. The ore is therefore of non-Bessemer grade. Small quantities of manganese are found in the Clinton ore in places, especially in the South. The content of this mineral seldom exceeds 0.25 per cent. In the soft ore the lime generally runs less than 1 per cent, so that the percentages of the other constituents are proportionately higher.

GEOLOGIC RELATIONS AND DISTRIBUTION.

The Clinton formation, of which the Clinton ore beds are a part, consists of lenticular, overlapping sedimentary beds, chiefly shale, sandstone, and limestone. In some places shale predominates, in others sandstone, and less commonly limestone. One or more iron-ore beds are generally present, although over considerable areas none occur.

The formation has a wide distribution in the eastern half of the United States. In the Mississippi Valley it is present in Wisconsin and Missouri, in the latter State having been recognized in a drill hole by the presence of a bed of iron ore over 8 feet thick at a depth of 2,000 feet. In eastern Wisconsin the formation is represented by a bed of iron ore only, which varies in thickness from 1.5 to 25 feet. In Ohio, Indiana, and northeastern Kentucky the formation occurs generally with thicknesses of 35 to 50 feet, but containing ore only in the latter State. In northern New York the Clinton rocks extend in a east-west strip from Niagara River to Otsego County. Here the thickness ranges from 32 to 295 feet. In all these States the beds are approximately horizontal or dip at very low angles. In the Appalachian belt from northern Pennsylvania southwestward to central Alabama the Clinton is a well-developed formation, and the beds are generally inclined at angles varying from 10° to 90°. The thickness of the formation decreases from 2,000 feet in Pennsylvania to about 850 feet in Virginia, 300 to 750 feet in Tennessee, and 200 to 700 feet in Alabama and Georgia.

While the total length of outcrop of all the areas of ore-bearing Clinton formation would reach several thousand miles, only a relatively small part of this outcrop contains ore workable under present conditions. The workability of an ore bed depends on its thickness, extent, composition, and attitude, and also upon its situation with respect to transportation routes, fuel, and markets. The first set of factors are of greatest importance, since few areas of good ore are so inaccessible that they will not sooner or later be reached by railroad. Local conditions also play an important part in determining the workability of an ore bed. For instance, in districts where several such beds occur in the formation, as in Alabama, only the thicker and richer ores are now worked, while others that would be at once exploited if they were in Pennsylvania are for the present neglected.

Wisconsin.—In Wisconsin Clinton ore has been produced in Dodge County since 1849. The ore occurs at Iron Ridge in an irregular lens-shaped bed between the "Cincinnati shale" and the Niagaran limestone. Its thickness varies from 1.5 to 25 feet. At other points, within a radius of 10 miles, the same ore bed occurs and it is known to thin out to the east. Toward the west the ore has been eroded, so that the outcrop lies in a westward-facing scarp about 60 feet high, capped by Niagaran limestone. Open-cut and underground mining have been carried on here. The ore as originally mined ran low in lime and contained about 45 per cent iron. It was partially hydrated and represented the "soft ore" of the outcrop. In 1906 the production of ore from Iron Ridge was nearly 90,000 tons, and in 1907 about 22,000 tons. Recent exploration work has proved that a considerable reserve of hard ore remains in this district, amounting to about 40,000,000 tons.

Kentucky.—A bed of Clinton ore, averaging probably more than 2 feet in thickness, occurs in Bath County, Ky., underlying an area of about 8 square miles. This ore lies nearly horizontal, but most of it is below too heavy cover to admit of mining under present conditions. It carries from 30 to 40 per cent iron and 13 to 16 per cent lime carbonate. At present the ore is mined by stripping where the cover is not more than 8 to 10 feet thick. The deposit has produced approximately 190,000 tons, and it is estimated that there are remaining 25,000,000 tons, one-tenth of which may be available under present conditions.

New York.—The belt of ore-bearing Clinton within New York State extends from Rochester on the west nearly to Utica on the east, a distance of about 130 miles. The width of outcrop of the formation reaches a maximum of 5 miles. The beds dip toward the south, from

45 to 80 feet to the mile. Conditions are extremely favorable for underground mining and should permit work to a distance of 3 to 5 miles from the outcrop wherever the ore is of sufficient thickness. The ore bed that is worked varies in thickness from 1.5 to 4 feet, with an average of about 2.5 feet. It carries 35 to 45 per cent of iron, with an average, where worked, of about 40 per cent. The phosphorus is high, from 0.25 to more than 1 per cent, and the sulphur, while variable, runs from traces up to 0.5 per cent. The ore has been worked in Wayne, Cayuga, and Oneida counties.

An estimate made by the New York State Survey of the tonnage contained in this district, mainly in these three counties, gives a total of 600,000,000 tons. Ore beds less than 1.5 feet thick and at a depth of more than 500 feet, as well as those carrying less than the average content of iron, have been excluded from consideration. Much of this ore, however, is not available under present conditions.

Pennsylvania.—The length of outcrop of the Clinton formation in Pennsylvania is very great owing to its repetition in the many anticlinal folds within the central part of the State. In the counties of Snyder, Mifflin, Juniata, Blair, Huntingdon, and Bedford, three or four thin beds of red ore occur, ranging in thickness from a few inches to more than 2 feet. The ore on the outcrop is usually soft and rich enough to work by stripping, but the hard ore under cover is in most places too thin to be worked at present. In a few places, however, where the beds are from 1 to 2 feet thick, underground drifts and slopes have been driven for short distances in the hard ore. The soft ore carries 40 to 50 per cent of iron and from a trace to 5 or 6 per cent of lime. The hard ore carries 20 to 35 per cent of iron, and in places as much as 25 per cent of lime.

Less than 20,000 tons a year of Clinton ore are now being produced in Pennsylvania, and it is probable that the reserves of this ore at present available in the State are not much in excess of 5,000,000 tons.

Virginia and north Tennessee.—The ore beds in the Clinton in Virginia are generally too thin to be considered important reserves after the soft ore shall have been mined out. In the west-central part of the State beds at Lowmoor range in thickness from 16 to 21 inches, and at Iron Gate from 8 to 12 inches. The soft ore carries 46 to 57 per cent of iron. Nearly 90,000 tons were shipped in 1907 from mines in this district, and at this rate of production most of the easily accessible soft ore will probably be exhausted within ten or twelve years.

The Clinton formation, outcropping along the foot of Cumberland Mountain, is ore-bearing from Cumberland Gap, Va., to La Follette, Tenn. Near Cumberland Gap there are three ore beds ranging in thickness from 6 inches to 2.5 feet. Only the upper bed, the thickness of which ranges from 15 to 20 inches, is workable. Southwestward toward La Follette the ore increases in thickness to 3.5 feet. Here practically all the soft ore has been mined out, so that only a hard ore, carrying 26 to 32 per cent of iron, remains. It is estimated that about 16,000,000 tons of such ore are still available in the Cumberland Gap-La Follette district.

It is possible that future exploration of the extensive areas of Clinton formation within Virginia and West Virginia may reveal additional ore reserves.

Rockwood-Chattanooga-Gadsden district.—This district embraces an area about 30 by 125 miles in the Appalachian valley region of east Tennessee, northwest Georgia, and northeast Alabama. Steeply dipping Clinton strata outcrop in narrow strips on both sides of Walden Ridge and Lookout Mountain and in the Whiteoak Ridge and other synclines of the Tennessee Valley. Ore is mined at North Chattanooga, Rockwood, Cardiff, Euchee, Welker, and Ooltewah, Tenn., and has been mined extensively at Inman. The important mining localities in Georgia are at Rising Fawn and Estelle, and in Alabama at Battelle, Portersville, Crudup, Attalla, and Gadsden.

The workable ore beds range from 2 to 5 feet in thickness and carry from 30 to 40 per cent of iron, 10 to 25 per cent of lime, and 0.5 to 0.7 per cent phosphorus. The use of much of the ore that is low in iron and high in lime depends upon the continuance of supplies of brown ore. The latter is mixed in the blast furnace with red ore that contains more than sufficient lime to be self-fluxing.

Estimates based upon fairly complete examinations place the available Clinton ore of the Rockwood-Chattanooga-Gadsden district at 86,570,000 tons, and the ore that will ultimately become available at 440,000,000 tons.

Birmingham district.—The Birmingham district includes the Clinton ore-bearing areas of Alabama from Springville southwest beyond Woodstock. As in Tennessee and Georgia, the Clinton formation in Alabama outcrops in narrow strips on the flanks of synclinal mountains. The dips range from 10° or 15° to vertical. The most important outcrop is along the crest of Red Mountain for about 25 miles near Birmingham. Other areas of minor importance occur along West Red Mountain near Birmingham. The thickness of the more important ore beds ranges from 2.5 to 12 feet. The ore carries from 30 to 40 per cent of iron, 10 to 25 per cent of lime, 0.3 to 0.6 per cent phosphorus, and from a trace to 0.1 per cent sulphur.

Estimates of tonnage of available ore for the Birmingham Clinton ore field indicate a supply of probably 358,470,000 tons, and of ore not at present available of about 438,000,000 tons.

SUMMARY AND ESTIMATES.

The Clinton formation has a wide distribution in the central and eastern portion of the United States, but contains commercially important ore beds in only a part of its area. The most important deposits are in the Birmingham, Chattanooga, and New York State districts, while less extensive deposits occur in Virginia, Wisconsin, Pennsylvania, and Kentucky.

It is evident from the above description that the quantity of ore contained in any area of the Clinton formation may be calculated with a fair degree of accuracy, provided sufficient data are available as to its dip and as to variations in thickness and quality of the ore beds. An assumption must be made as to depth-limiting workability under a variety of structural conditions, and since this is a matter of opinion it will vary somewhat widely and introduce corresponding differences in the results. Conditions of blast-furnace practice locally may define the quality of a workable ore. In places where brown ores are available for mixing with Clinton ores, an ore of the latter class can be used as a flux, although it runs so low in iron and so high in lime that alone it would not be acceptable. The estimates of available ores made by various experts do not, however, differ materially. In case of the total ore which is not now available, but which may be mined eventually, the variance in estimates is much greater, since more unknown factors enter into the problem.

The estimates given below are based upon detailed examinations of the more important districts by the United States Geological Survey for the Birmingham and Chattanooga districts, and by the State Survey for the New York district, with a study of all obtainable drill records.

Estimates of Clinton ores.

District.	Available.	Not available.
	Long tons.	*Long tons.*
Birmingham	358,470,000	438,000,000
Chattanooga	86,570,000	440,000,000
New York	30,000,000	570,000,000
Virginia-North Tennessee	16,000,000	50,000,000
Wisconsin	10,000,000	30,000,000
Pennsylvania	5,000,000	50,000,000
Kentucky-West Virginia	2,500,000	42,500,000

(4) APPALACHIAN METAMORPHIC ORES.

This group includes the deposits of magnetite and specular hematite associated with the crystalline and metamorphic rocks of the Piedmont and Appalachian mountain belts, which extend from southern New York to central Alabama. The ore deposits are not uniformly distributed throughout this area, but are confined to certain portions where geologic conditions have been favorable for their accumulation. The most important districts are (1) the highlands of southern New York and northern New Jersey; (2) the James River district, Virginia; (3) the Cranberry district, North Carolina; (4) the Piedmont district, North Carolina; (5) the Yorkville district, South Carolina; (6) the Talladega gray ore district, Alabama. The last-named district is included in this group for convenience, although it differs materially in its geologic relations from the others.

The ore deposits of this group have the form of lenticular beds or elongated pods, which are interlaminated with the gneisses, schists, or crystalline limestones. The individual deposits vary in thickness from a fraction of an inch up to 50 or even 80 feet, but the majority of the workable deposits are from 4 to 15 feet thick and are apt to show rapid variations by pinching and swelling on both the strike and the dip. They vary in composition from practically pure iron ore to a material containing a large proportion of gangue minerals. In general, the larger deposits contain the smaller proportion of iron and can be worked only by the employment of some method of concentration.

The deposits rarely occur singly, but are more often disposed in rather narrow belts separated by wider belts of barren gneiss and schist. Since the ores were undoubtedly derived from a deep-seated source, there is no reason to anticipate a failure in depth, although pinches and swells are to be expected in the course of deep mining, and the cost of mining will necessarily increase with depth.

The gray hematites of the Talladega district and certain hematite deposits of Virginia and Georgia are here included for convenience, though they occur under entirely different geologic conditions from those above described. These hematites have the appearance of regularly bedded deposits, associated with sedimentary rocks which have suffered only slight metamorphism. Whether or not they were deposited at the same time as the inclosing sediments has not been definitely determined. They possess much greater uniformity, both on the dip and along the strike, than the magnetites in the crystalline rocks, and for practical purposes may be regarded as original bedded deposits.

In view of the irregularities in thickness of the magnetite beds, which can not be determined in advance of thorough prospecting, it is impossible to make any accurate calculation of the amount of ore which they contain even when their area at the surface is known, and this is rarely the case. The following estimates, therefore, are only approximate, particularly the amount assigned to the nonavailable class:

Estimates of Appalachian metamorphic ores.

Ores.	Available.	Not available.
	Long tons.	*Long tons.*
Magnetites, including some titaniferous magnetites and some hematite	47,500,000	74,500,000
Specular hematites, including some limonites	8,000,000	53,000,000

(5) APPALACHIAN BROWN ORES.

This group embraces those deposits of brown ores associated with the Appalachian belt of closely folded sedimentary rocks which extends continuously from northern Vermont southwestward to central Alabama. It is bounded on the east by the older crystalline and metamorphic rocks of the Appalachian Mountains, and on the west by the younger "Coal Measures." It is underlain by limestones, dolomites, shales, sandstones, and quartzites, ranging in age from Cambrian to Carboniferous. The beds, originally deposited in approximately horizontal layers, have been folded and faulted so that they now occupy all possible attitudes. This has given rise to conditions favorable to the rapid weathering of the rocks. The steeply dipping sandstones and quartzites form sharp ridges, while the more easily eroded limestones, dolomites, and shales form the intervening valleys, their surfaces being generally covered with a deep mantle of residual materials. These rocks, particularly the shales and some of the limestones, contain small quantities of iron minerals, sulphides, carbonates, and silicates, and in the process of weathering and erosion, by which many thousand feet of strata have been removed, the iron originally contained in these widely disseminated minerals has been concentrated, where conditions were favorable, as the hydrated oxide forming the deposits of brown ore. These deposits, while presenting great diversity in form, fall into three classes, known as mountain ores, valley or limestone ores, and Oriskany ores.

MOUNTAIN ORES.

These deposits are so called because they always occur upon the flanks or at the base of a sandstone, chert, or quartzite ridge, and throughout Virginia, Tennessee, Georgia, and Alabama they are most extensively developed along the extreme eastern margin of the valley belt where the Cambrian quartzite forms a high ridge flanking the crystalline rocks. The quartzite beds dip steeply beneath the overlying shales and limestones, and iron derived from the latter during the process of weathering has been concentrated downward upon this impermeable foot wall. Similar conditions favorable for ore concentration occur elsewhere in the Appalachian belt where the Cambrian quartzite in isolated ridges dips beneath the overlying shales, as at Anniston, Ala., and also at a few points where the lower Carboniferous chert has formed an impermeable foot wall, as at Sugar Valley, Ga. The deposits present great diversity in form, varying from fissure veins and replacement zones in the sandstone and shale, through blanket deposits resting on the quartzite, to irregular pockets scattered through the residual clay. The last are the most abundant and characteristic. Their size can rarely be determined in advance of development, even by systematic prospecting, and estimates of their available tonnage vary between wide limits.

VALLEY OR LIMESTONE ORES.

These are associated with the great limestone and dolomite formations which underlie much of the Appalachian belt. They are also derived from the iron minerals originally disseminated through the rocks and have been concentrated during the process of weathering and erosion. Their location depends on the original abundance of these minerals in the rocks and on favorable conditions for concentration afforded during erosion, in some cases probably by the fracturing of the beds and the consequent free underground circulation of water, and in others by the location of an easily soluble bed of limestone toward which drainage from surrounding areas brought the iron and deposited it as bog ore. They are always embedded in the residual mantle composed of the insoluble portions of the underlying rocks. The deposits vary in form, but generally consist of concretionary masses ranging in size from those containing several tons down to pellets the size of a pea, disseminated through the residual clay.

ORISKANY ORES.

These deposits are more regular in their occurrence, being limited to a definite horizon in the Helderberg limestone immediately beneath the Oriskany sandstone. They are confined to a comparatively small portion of the valley belt, chiefly in southwestern Virginia with a few deposits in Pennsylvania and West Virginia. The iron was originally disseminated in the overlying shales, and wherever these shales occurred in sufficient thickness and the limestone bed occupied a favorable attitude its lime carbonate has been replaced by the iron oxide for a greater or less distance below the surface. The deposits frequently extend continuously for several miles along the outcrop, being made up of a series of lenses which may reach 75 feet in their thickest portions and thin down to a foot or less where adjacent lenses come together. The greatest depth to which the ore has been found is about 600 feet. Where the replacement has been complete and extensive, therefore, it has the form of a bedded deposit and the ore content can be estimated with some certainty. The deposits consist either of fairly solid ore or of irregular masses and seams of ore embedded in clay.

DEVELOPMENT AND ESTIMATES.

The Oriskany deposits are mined both by stripping on the outcrop and by regular underground mining. The mountain and valley ores are nearly always mined in open pits, in the larger operations by steam shovel, and in a few cases by the hydraulic method. Where hand mining is done, a part of the ore is sent direct to the furnace without other treatment than hand picking, but where the steam shovel is used everything is passed through the washer. In most cases sorting tables and jigs are employed in addition to the washer. By these means the associated materials, consisting of clay, chert, and other rock fragments, are removed from the ore. The average iron content of the ore as shipped is about 45 per cent, and the phosphorus is generally above the Bessemer limit. The deposits of this group, being widely disseminated and easily mined in open pits, furnished a large part of the ores used by the small charcoal furnaces in the early development of the iron industry in the United States. With increase in capacity of furnaces a more reliable ore supply has been sought, and many districts which were formerly heavy producers have been temporarily abandoned. The ore is still in demand, however, chiefly for mixture with the calcareous Clinton ores, and its production will doubtless increase in the future beyond any point previously reached.

From the above description of these brown-ore deposits it will be readily understood that extreme difficulty must attend any attempt to estimate their total tonnage. It is unsafe to base an estimate on the number of known occurrences of the ore multiplied by an average content derived from the known yield of certain deposits which have been worked out, for the best deposits are the ones most apt to be exploited first. The estimates given below are based in part on systematic examination and measurement of all known deposits in certain districts and in part on general considerations of distribution and geologic occurrence. The amounts given in the second column of the table, representing ore not now available, are confessedly little better than guesses and future exploration may show them to be much too low. It should be stated further that estimates made by competent experts differ from the figures here given by a factor varying from 0.7 to 3.

Estimates of Appalachian brown ores.

	Available.	Not available.
	Long tons.	*Long tons.*
New England and New York	1,000,000	1,500,000
Pennsylvania, Maryland, and New Jersey	10,000,000	12,000,000
Virginia, West Virginia, and East Tennessee	35,150,000	136,000,000
Alabama, Georgia, and North Carolina	19,250,000	32,000,000

(6) APPALACHIAN CARBONATE ORES.

This group of deposits includes the beds of carbonate ores and their oxidized outcrops which occur in the Carboniferous rocks within a broad belt stretching from western Pennsylvania through Ohio into northeastern Kentucky, and probably extending also into Tennessee and Alabama. The rocks occupying this belt are chiefly sandstones and shales, with occasional thin beds of limestone. The beds are nearly horizontal, and the topography is such that the outcrop of any stratum is extremely sinuous and may have a length many times the shortest distance between two points. This combination of structure and topography has an important bearing on the possible utilization of the iron ore.

The group embraces several varieties of ore locally distinguished as limestone ore, block ore, kidney ore, and black-band ore, each of which is accompanied by a corresponding variety of oxidation product. All of the varieties are non-Bessemer ores. The limestone ores are associated with thin beds of limestone, the most widely distributed being the Vanport and Maxville. The ore beds lie immediately above the limestones, which they sometimes entirely replace. They are usually only a few inches thick, but occasionally expand to several feet. For varying distances from the outcrop the original iron carbonate has been oxidized to a dense brown ore, with loss of carbonic acid and increase in proportion of iron. The unaltered carbonate contains 30 to 35 per cent iron, and the alteration product from 43 to 47 per cent.

The block ores are fairly regular bands of iron carbonate, interstratified with shale or fine sandstone. They are more persistent and uniform in thickness than the other varieties. In Kentucky three persistent beds are recognized having a total outcrop of over 450 miles. The quality of the ore varies inversely with the thickness of the beds, the thinnest beds carrying the best ore. The unaltered carbonate carries from 29 to 34 per cent iron, and the brown ore on the outcrop from 33 to 43 per cent.

The kidney ores, as their name implies, are concretionary in form and occur in certain beds of clay shale, rarely forming continuous layers. They grade into the black-band ores, which are usually more or less closely associated with coal beds and contain carbonaceous matter which gives them a black color. These concretionary forms generally contain the purest iron carbonate and on oxidation at their outcrop yield a correspondingly pure limonite, or brown ore.

In the early history of iron making in the United States this ore belt in Pennsylvania, Ohio, and Kentucky contained a large number of small charcoal furnaces and the aggregate amount of ore produced was very considerable. With the disappearance of the forests the iron industry in this region declined, and the use of these ores has practically ceased. The production was confined largely to the oxidized surface ores, which not only were more easily accessible but gave the best results in the primitive furnaces. While the deposits of this group contain a large aggregate tonnage, practically all of it must be classed as not at present available. The principal reason that the ore can not now be worked at a profit is the fact that the nature of the deposits does not permit operations on a large scale. At only a few points are the beds sufficiently thick and persistent for underground mining, and stripping is therefore the method used. The distance which stripping can be carried into the hillside depends on the slope and the thickness of the bed. An average width of the belt from which the ore can be mined has been assumed as 100 feet, and the average thickness of the ore bed from 10 to 12 inches. The aggregate length of outcrop of the several ore beds has been taken as follows: For Pennsylvania, 866 miles; Ohio, 2,056 miles; and Kentucky, 1,260 miles. With these assumptions the total tonnage of carbonate and associated limonite ores which may ultimately be produced in these three States, and in Tennessee and Alabama, is as follows:

Estimates of Appalachian carbonate ores.

	Available.	Not available.
	Long tons.	*Long tons.*
Pennsylvania		46,000,000
Ohio		200,000,000
Kentucky		60,000,000
Tennessee-Alabama		2,000,000

(7) WEST TENNESSEE BROWN ORES.

This group embraces the ore deposits within a broad belt extending from the northern border of Alabama and Mississippi across western Tennessee and Kentucky. This region is a plateau of moderate elevation which has been dissected by the Tennessee River and its tributaries. The rocks underlying the ore-bearing territory are lower Carboniferous cherty limestones. The ore deposits closely resemble the limestone ores of the Appalachian Valley. They vary in size from scattered concretions embedded in surface cherty clay to bodies having a depth of 120 feet or more and containing upward of half a million tons. The larger deposits are confined to slight depressions in the plateau surface, in which deposits of waterworn bowlders suggest the former presence of streams. The ore was doubtless derived from the accumulation during the process of weathering and erosion of iron contained in minerals disseminated through the higher formations. These ores have been mined for many years, supplying a number of local charcoal furnaces and being shipped for mixture with the calcareous Clinton ores of the Chattanooga and Birmingham districts.

In the absence of detailed examination of this ore belt, estimates of ore tonnage contained in these deposits must rest upon a very small foundation of ascertained fact. A few of the deposits have been studied, as those at Russellville, Mannie, and Goodrich, and the estimates for the entire district are based upon these disconnected observations. These estimates place the available ore at 10,000,000 tons, and the ore not now available, chiefly because of the excessive cost of transportation and of working scattered deposits, at 15,000,000 tons.

(8) EAST TEXAS BROWN ORES.

This group of deposits occurs in the northeastern portion of Texas and the adjacent portions of Louisiana and Arkansas. They differ materially in their geologic relations and in the problems of utilization from the brown ores previously described. The region is underlain by Tertiary formations, chiefly unconsolidated sands, clays, and greensands. The ore forms a fairly uniform layer, rarely averaging over 2 feet in thickness, and covering large areas. It is at places exposed at the surface and elsewhere covered by soil and sand to a depth of 6 feet or more. The ore averages about 46 per cent of iron, and is above the Bessemer limit in phosphorus. It is generally high in both silica and alumina. The deposits are probably derived from the oxidation in place of beds and nodules of iron carbonate, although it may be in part due to the concentration of iron derived from the greensand and other iron minerals disseminated through adjacent formations. While these deposits contain in the aggregate a large amount of ore of fairly good grade, its utilization presents somewhat serious difficulties. Owing to the thinness of the deposits the ore can not be excavated with steam shovel or other mechanical devices. The scarcity of water in the region will prevent hydraulicking and also economical washing of the ore, so that only the lump ore can be utilized.

These deposits have been mined at a number of points and have supplied a local furnace for some years. The same region is underlain by beds of lignite, one of which at a depth of about 50 feet has a thickness of over 4 feet. Should it prove practicable to use this lignite in blast-furnace practice, directly or as a gas producer, its occurrence in the immediate vicinity of the ores would prove highly advantageous in their utilization.

In the absence of detailed surveys it is not possible to closely estimate the area of the workable deposits. The total area known to be underlain by the ore-bearing formation is about 500 square miles, and of this probably 50 square miles contain a bed averaging 2 feet in thickness, which is taken as the limit of profitable working at the present time. Upon this basis the district is estimated to contain 260,000,000 tons of available ore, and it is probable that it contains twice this amount of ore that is not now available but will be utilized eventually.

(9) OZARK ORES.

[Based on reports of the Missouri State Survey.]

The Ozark district embraces the southern half of Missouri and a narrow strip along the northern border of Arkansas. It consists of a broad, unsymmetrical, domelike uplift, by which the older rocks are brought to the surface near the center of the district and, dipping outward in all directions, pass under successively younger formations toward its circumference. The oldest rocks in the district are igneous, porphyry and granite, on the irregularly eroded surface of which the Cambrian formations were deposited. The greater part of the district is occupied by cherty, magnesian limestone, with subordinate sandstones and shales.

The district contains four classes of iron ores in deposits of sufficient size to be of commercial importance. These are (1) coarse specular hematite, occurring in veins in porphyry and in associated conglomerate beds; (2) fine specular hematite, occurring in pockets at the contact between Cambrian sandstones and limestones; (3) brown ore, limonite, occurring in pockets in the residual clay and chert derived from the weathering of limestones; and (4) red hematite, occurring as bedded deposits with Carboniferous shales and sandstones. In addition the "Coal Measures" contain occasional thin beds of iron carbonate, but these are not known in deposits of commercial size. Each of these classes of ore being associated with certain geologic formations, their distribution is dependent on the structure of the district. The porphyry ores are confined to a small district in Iron County, practically to the two localities, Iron Mountain and Pilot Knob. The fine hematites are grouped within an area about 50 miles in diameter, chiefly in Phelps and Crawford counties, where the Roubidoux sandstone occupies the surface. The limonite deposits form two irregular groups, the first occupying the basin of the Osage River and the second extending along the southeastern margin of the district. The deposits of the red hematite are less numerous than the other kinds, and occur chiefly along the northern margin of the district.

SPECULAR PORPHYRY HEMATITE.

The interest in these deposits is chiefly historic, since they are now practically exhausted and thorough testing in the most favorable localities has entirely failed to reveal additional deposits. These were the first iron ores worked west of the Mississippi River and supplied several local furnaces, the first of which was built about 1815. They continued to produce up to 1893 and have had a total production of 4,500,000 tons. The history of the development and exhaustion of these deposits is instructive as illustrating the fallacy of the popular belief that many ore bodies are inexhaustible and showing that they are very definitely limited in the amount of ore which they will yield.

SPECULAR SANDSTONE HEMATITE.

These deposits consist of irregularly circular pockets from 300 to 500 feet in diameter, located in the sandstone and extending downward into the underlying limestone. The ore occurs both as bowlders mixed with fragments of sandstone, chert, and residual clay and as a solid, indistinctly bedded mass. The unaltered ore is a dense, fine-grained blue or gray hematite, which near the surface has been changed largely to soft red hematite or to limonite. The better grades contain 55 to 67 per cent of iron and are generally low in phosphorus. In addition there are large amounts of siliceous ore which are not available under present conditions. The yield of individual deposits may be in excess of half a million tons, and unless erosion has cut into deposits of this size they may afford little or no indication of their presence at the surface. In the absence of thorough testing, surface indications are therefore unreliable as a basis for estimates of the ore content of these deposits. A large amount of uncertainty must be present in any estimate of total tonnage, and the figures given are regarded only as roughly approximate. These deposits at present form the chief source of iron-ore production in the Ozark district.

BROWN ORES.

Deposits of this class occur in very large numbers as irregular pockets in the residual material overlying various limestone formations. They are due to the concentration of iron contained in minerals originally disseminated through the rocks which have been removed and were concentrated during the process of weathering and erosion. They are in part also derived from the solution and redeposition at lower levels of other iron ores, as the specular and red hematites. Over 500 localities are listed at which these deposits occur, and while they vary widely in the amount of ore contained, the aggregate tonnage must be very considerable. Owing to the small size of many of these deposits, their distances from transportation places them in the class of ores not at present available. Also, in a considerable proportion of the deposits, the ratio of ore to clay is too low for profitable working at present.

RED HEMATITE.

These ores occur as regularly bedded deposits in certain portions of the lower Carboniferous formations along the northern border of the Ozark district. They are variable in thickness and horizontal extent. The deposits are practically undeveloped, and owing to the low grade of the ore and the thinness and variability of the beds, they can not at present compete with other ores of higher grade and more cheaply mined.

SUMMARY.

The estimates of tonnage contained in the various classes of ore deposits in the Ozark district are summarized in the following table:

Estimates of Ozark ores.

	Available.	Not available.
	Long tons.	*Long tons.*
Sandstone hematite	15,000,000	5,000,000
Brown ore	30,000,000	45,000,000
Red hematite	....	5,000,000

(10) ROCKY MOUNTAIN METAMORPHIC ORES.

This group embraces the deposits of magnetite and specular hematite associated with crystalline schists and gneisses at various localities in the Rocky Mountain region. They are similar in most particulars to the deposits of the same ores in the crystalline metamorphic belt of the Eastern States. They consist of lenticular beds conforming in dip and strike to the foliation of the inclosing rocks and varying greatly in thickness within short distances, both in depth and along the outcrop. Associated with these beds, and evidently derived from them, are occasionally found secondary fragmental deposits, which are sometimes overlain by later sedimentary or igneous formations.

The best-known deposits of this group occur in the Hartville district, Wyoming, and in the Llano district, Texas. They also occur at various points in Colorado, Nevada, New Mexico, and Arizona, and in general may be expected wherever there are considerable areas of crystalline gneisses and schists. They have been extensively worked in the Hartville district, supplying a part of the ore for the furnaces at Pueblo, Colo., and being used also to some extent for fluxing silver ores. It is probable that a much larger proportion of the deposits of this group are as yet undiscovered than of any other group of iron-ore deposits. In view of the extremely meager information, estimates of their contents have little value. The ore is generally high grade, though sometimes siliceous, but a large proportion of the deposits are not at present available by reason of remoteness from transportation lines and distance from suitable fuel for their reduction.

(11) IGNEOUS CONTACT ORES.

This group is based exclusively upon its geologic relations, and the deposits are widely distributed, though the most of them are located in the Rocky Mountain and Pacific States. The essential characteristics of the deposits are the following: They are steeply dipping, lens-shaped bodies, which closely follow the contact of an intrusive igneous mass and an intruded limestone. They occur partly within the igneous rock as dikelike veins and partly within the limestone, but generally at the immediate contact. The limestone is always altered for a variable distance, sometimes several hundred feet from the contact, the alteration consisting in extreme silicification and the development of lime-bearing metamorphic minerals. The ores are magnetite, or more generally an intimate mixture of magnetite and hematite. They are often altered at the surface to red hematite and to some extent to limonite. The original bedding planes of the limestone are sometimes preserved in the ore body. The gangue consists of quartz and aluminous silicates, in part the recrystallized impurities of the limestone and in part minerals introduced along with the iron. The ores are believed to be due to hot solutions rising from a deep-seated source through fissures in the igneous rock at a period closely following its complete or partial solidification.

CORNWALL DISTRICT, PENNSYLVANIA.

The principal eastern representative of this group is in eastern Pennsylvania, where the ore, chiefly magnetite, has been mined since the early part of the eighteenth century. These deposits, of which the Cornwall mine is considered the type, occur at the contact of intrusive masses of Mesozoic diabase and Cambrian limestone. The more easily accessible portions of the deposits have been mined out, but they are estimated to contain 50,000,000 tons of ore, of which about 15,000,000 tons are considered available under present conditions.

IRON SPRINGS DISTRICT, UTAH.

These are the best known of the western representatives of the group. They are located in southwestern Utah, about 250 miles from Salt Lake. The ore, which consists of both magnetite and specular hematite (70 per cent of the former and 30 per cent of the latter), occurs at or near the contact of laccolithic intrusions of andesite in Carboniferous limestone. The aggregate surface of the known ore bodies is 5,430,000 square feet, and the calculated tonnage to a depth of 130 feet is 40,000,000 tons. While this is the greatest depth at which the ore has been actually observed in prospect pits, a careful consideration of its geologic relations leads to the conclusion that it extends to considerably greater depths, and probably twice the above tonnage may be taken as the amount which is present but not now available. Practically no development has taken place except the sinking of a large number of prospect pits.

OTHER DISTRICTS.

Ore deposits belonging to this group are known to occur at numerous localities throughout the West, but they have not generally been examined in sufficient detail to permit accurate estimates of tonnage being made.

In Utah deposits occur at Bull Valley, about 25 miles southwest of the Iron Springs district and under similar geologic conditions. In California they are found in the Cave Canyon and other districts in San Bernardino County, in the Eagle Mountain district, Riverside County, in Shasta County, and elsewhere. In Nevada large deposits, estimated to contain at least 7,000,000 tons of magnetite and hematite, averaging 63 per cent of iron, are reported to occur in the Lovelocks district, in Humboldt and Churchill counties. Deposits also occur in Lyon County. In Washington deposits which probably belong to this group, although their relations are not known in detail, occur at a number of localities in the northeastern part of the State, in Stevens County. The ores are chiefly magnetite and hematite, though in part altered to limonite.

In Colorado iron-ore deposits occur near Ashcroft, in Pitkin and Gunnison counties, and in the White Pine and Cebolla districts, in Gunnison County. Those of the Ashcroft district occur on both sides of the Elk Mountains, at elevations between 11,000 and 12,000 feet above tide. The deposits are associated with limestones and igneous intrusives. They are of considerable size, the one on the northwest side of the divide being at least 300 feet on the strike and from 40 to 122 feet thick. Its total depth is not known, but it is proved to be at least 100 feet. The greater part of the ore is high in iron and sulphur, but low in phosphorus.

In New Mexico iron-ore deposits occur at Chupadera Mesa and at Fierro, in Grant County. The latter locality has been worked for some years, furnishing a large amount of ore for the Pueblo furnaces. The ore is associated with limestones and igneous intrusions, forming lenses at or near the contact between the two. It is accompanied with metamorphic minerals, as epidote and garnet, which are developed in the contact zone in great abundance. The ore is magnetite with subordinate amounts of hematite, and usually contains a small amount of copper. The greater part of the easily accessible high-grade ore has been mined out.

COMMERCIAL CLASSIFICATION AND SUMMARY OF ESTIMATES.

While the foregoing classification and grouping of the iron-ore deposits is a convenient one for purposes of description and for discussion of the basis and value of tonnage estimates, the grouping does not correspond with commercial conditions, and the estimates already given are therefore summarized by commercial grades and districts in the following table:

Estimates of iron-ore supplies of the United States.

Commercial districts (States).	Magnetite ores.			
	Nontitaniferous.		Titaniferous.	
	Available.	Not available.	Available.	Not available.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
1. Northeastern	160,000,000	111,500,000	90,000,000	100,000,000
2. Southeastern	[a] 12,500,000	23,000,000	....	....
3. Lake Superior	....	4,500,000,000	....	25,000,000
4. Mississippi Valley	....	....	....	....
5. Rocky Mountain	[a] 51,485,000	[a] 115,440,000	....	1,500,000
6. Pacific Slope	[a] 68,950,000	11,800,000	....	2,000,000
Total	292,935,000	4,761,740,000	90,000,000	128,500,000

Commercial districts (States).	Hematite ores.			
	Specular and red.		Clinton.	
	Available.	Not available.	Available.	Not available.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*
1. Northeastern	2,000,000	2,000,000	35,000,000	620,000,000
2. Southeastern	8,000,000	53,000,000	463,540,000	970,500,000
3. Lake Superior	3,500,000,000	67,475,000,000	10,000,000	30,000,000
4. Mississippi Valley	15,000,000	10,000,000	....	....
5. Rocky Mountain	4,275,000	2,100,000	....	....
6. Pacific Slope	....	10,000,000	....	....
Total	3,529,275,000	67,552,100,000	508,540,000	1,620,500,000

Commercial districts (States).	Brown ores.		Carbonate ores.		Total supplies.	
	Available.	Not Available.	Available.	Not Available.	Available.	Not Available.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
1. Northeastern	11,000,000	13,500,000	....	248,000,000	298,000,000	1,095,000,000
2. Southeastern	54,400,000	168,000,000	....	62,000,000	538,440,000	1,276,500,000
3. Lake Superior	....	....	....	....	3,510,000,000	72,030,000,000
4. Mississippi Valley	300,000,000	560,000,000	....	....	315,000,000	570,000,000
5. Rocky Mountain	2,000,000	1,625,000	....	....	57,760,000	120,665,000
6. Pacific Slope	....	105,000	....	....	68,950,000	23,905,000
Total	367,400,000	743,230,000	....	310,000,000	4,788,150,000	75,116,070,000

[a] Includes some hematite.

1. Vermont, Massachusetts, Connecticut, New York, New Jersey, Pennsylvania, Maryland, Ohio.
2. Virginia, West Virginia, eastern Kentucky, North Carolina, South Carolina, Georgia, Alabama, east Tennessee.
3. Michigan, Minnesota, Wisconsin.
4. Northwest Alabama, west Tennessee, west Kentucky, Iowa, Missouri, Arkansas, east Texas.
5. Montana, Idaho, Wyoming, Colorado, Utah, Nevada, New Mexico, west Texas, Arizona.
6. Washington, Oregon, California.

FOREIGN IRON-ORE SUPPLIES.

In addition to the ore supplies included in the table given above, certain foreign deposits are so situated that they must depend, at least to a considerable extent, upon the American market, and are therefore to be considered practically a part of the available reserves. The most important of these sources of foreign supply are located in Canada, Newfoundland, Cuba, and Mexico. None of these countries has an abundant fuel supply, and therefore either the fuel must be imported or the ore exported. The history of the iron industry indicates that the latter is most likely to occur, particularly when the industry is already established and the chief market for the finished product is near the fuel supply. This tendency may be interrupted by artificial means, such as bonuses and tariffs, but such interference with the natural course of industrial development is only temporary, and in the long run the industry will gravitate to the point of the lowest cost of production.

CANADIAN ORES.

Recent explorations have shown the existence of considerable areas of the iron-bearing formations on the north shore of Lake Superior. The total tonnage of the iron formation in the Animikie, Michipicoten, and other north-shore districts is calculated at 93,600,000,000 tons. If the same proportion of this total be considered low-grade ore as in the Michigan and Minnesota districts it will amount to about 20,000,000,000 tons. Since these north-shore districts are not as yet thoroughly prospected, the ratio between high and low grade ores can not be definitely determined, but it is almost certainly much lower than in the Michigan and Minnesota districts. The best estimate of ore now available in these Canadian districts is 9,000,000 tons.

Deposits of iron ore of the igneous contact type are known to occur in British Columbia, and those on Texada Island have been mined to some extent. These deposits are estimated to contain at least 30,000,000 tons of ore of present commercial grade and probably a considerably larger amount of low-grade and deep ore not now available.

NEWFOUNDLAND ORES.

The most important of these are Clinton ores occurring on Belle Isle. Their area is definitely known and the doubtful factors are the proportion of ore below present commercial grade and the amount of available ore in beds known to extend under the ocean. The supply of available ore has been estimated at 30,000,000 tons, and the amount not now available may be several times this amount.

MEXICAN ORES.

Large deposits of iron ore are known to occur in various parts of Mexico. They are chiefly of the igneous contact and gossan types, and no estimate of any value can be made of their available tonnage. Remoteness from centers of iron production will prevent their extensive exploitation for the present, and they are therefore to be regarded as wholly within the unavailable class.

CUBAN ORES.

By far the most important foreign source of iron ore, measured by the extent of the supplies and their accessibility, is Cuba. The deposits are of two kinds, specular hematites of the Santiago district and brown limonites of the Mayari, Moa, Baracoa, Cubitas, and Pinar del Rio districts. The hematites have been worked extensively since 1884, and for a number of years have furnished more than 50 per cent of the total iron-ore imports. They are estimated to contain about 9,000,000 tons of ore, about half of which is actually measured.

The limonites are widespread residual deposits derived from the weathering of igneous rocks. The ore contains from 43 to 52 per cent of iron, phosphorus below the Bessemer limit, and between 1 and 2 per cent of chromium. These deposits are as yet practically undeveloped, but the more important ones have been fairly well prospected, and it is estimated that they contain an aggregate of 3,000,000,000 tons, at least one-third and possibly one-half of which may be regarded as now available. Most of the deposits are located near the northern coast of the island, so that they have the advantage of cheap water transportation to all parts of the Atlantic seaboard. They are without question destined to play an important rôle in the iron industry of the United States.

SUMMARY OF FOREIGN SUPPLIES.

The total estimated foreign supplies of ore sufficiently high-grade and accessible to mining and transportation to be at present available, and so located as to affect the iron industry of the United States, are shown in the following table:

Estimated foreign iron ores.

	Long tons.
Canada:	
British Columbia, magnetite chiefly	30,000,000
Lake Superior district, hematite chiefly	9,000,000
Nova Scotia, Clinton hematite	4,000,000
Newfoundland, Clinton hematite	30,000,000
Cuba:	
Santiago district, hematite	5,000,000
Mayari, Moa, Baracoa, Cubitas, and Pinar del Rio districts (limonite)	1,500,000,000
Total	1,578,000,000

IMPORTS AND EXPORTS.

The total imports of iron ore since 1889 have been 3 per cent of the domestic production for the same period. They have shown great annual fluctuations, responding quickly to changes in industrial conditions. Since 1904 there has been a steady and rapid increase in imports, and this increase may be expected to continue in the future even more rapidly with the expanding development of the Cuban limonite deposits.

The extent to which foreign ores are now supplying the market is shown by the following table of imports:

Imports of iron ore from foreign countries, 1889–1907.

Year.	Cuba.	Newfoundland and Labrador.	Quebec, Ontario, etc.	Spain.	Other countries.[a]	Total.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
1889	243,255	14,450	4,091	298,568	293,209	853,573
1890	351,814	6,320	22,211	512,933	353,552	1,246,830
1891	257,189	....	2,126	323,771	329,778	912,864
1892	307,115	....	8,606	236,957	253,907	806,585
1893	349,977	....	372	99,640	76,962	526,951
1894	140,025	....	443	15,067	11,772	167,307
1895	367,255	....	....	77,594	79,304	524,153
1896	380,551	20,800	....	121,132	160,323	682,806
1897	383,820	29,250	....	66,193	10,707	489,970
1898	165,623	....	....	13,335	8,250	187,208
1899	360,813	77,970	....	145,206	90,093	674,082
1900	431,265	140,535	5,588	253,694	66,749	897,831
1901	526,583	[b] 79,360	163,383	180,810	16,814	966,950
1902	696,375	81,920	203,824	153,527	29,824	1,165,470
1903	613,585	[b] 86,730	169,681	94,720	15,724	980,440
1904	364,630	5,400	77,887	36,810	2,886	487,613
1905	539,935	5,600	104,096	191,861	4,159	845,651
1906	639,362	[b] 125,395	57,890	171,870	65,873	1,060,390
1907	657,133	89,685	26,878	296,318	159,154	1,229,168
Total	7,776,305	[a] 763,415	847,076	3,290,006	2,029,040	14,705,842

[a] Belgium, Brazil, British Columbia, England, France, French Africa, French West Indies, Germany, Greece, Italy, Mexico, Netherlands, New Brunswick, Norway, Nova Scotia, Oceania, Portugal, Sweden, Turkey in Asia, Turkey in Europe, Venezuela, etc.
[b] Includes Newfoundland only.

The exportation of iron ores has fortunately never assumed large proportions, as shown by the following table:

Exports of iron ore from the United States, 1899–1907.

Year.	Quantity.	Value.
	Long tons.	
1899	40,665	$76,297
1900	31,460	154,766
1901	64,703	163,465
1902	88,445	294,108
1903	80,611	255,728
1904	213,865	458,823
1905	208,017	530,457
1906	265,240	771,839
1907	278,208	763,422
Total	1,271,214	3,468,945

This export consists chiefly of Lake Superior ores shipped to Canadian furnaces for mixture with local ores. It contains also some high-phosphorus ores from the Adirondack district shipped to Germany. This movement has practically ceased, owing to increased home demand for these ores.

WASTE IN MINING AND REDUCTION.

Where iron ore occurs in the form of bedded deposits and is mined underground, waste is apt to occur from the same causes as in coal mining. These are the leaving of pillars to support the roof, often unnecessarily large, the leaving of low-grade ore in the mine where it can subsequently be recovered only with difficulty, if at all, and the breaking down of an overlying bed where the lower of two beds in the same territory is mined first. These sources of waste are confined largely to the Clinton ores, and the available facts are insufficient for closely estimating its amount, but the proportion of recovery varies with local conditions between 75 and 90 per cent and is undoubtedly increasing with improvement in mining methods. In computing the available tonnage of the Clinton ores an average recovery of 75 per cent has been assumed. Portions of the Clinton ore beds at present considered of no value because of shale partings and consequently left in the ground might be mined at many points if the shale could be separated from the ore economically. Improvement in cleaning and concentrating methods will undoubtedly make the recovery of much ore of this character possible. In the steeply dipping magnetite and hematite beds practically all ore up to the required grade is mined out, and the ground is generally left in such condition that the mines can be reopened for the recovery of lower-grade ores.

In surface workings waste is confined largely to small operations where quick returns are required, and systematic development is impossible. In such cases much ore is lost by dumping barren strippings and low-grade ore together, so that it can be recovered only with difficulty, if at all. Where the operations are on a large enough scale to warrant the installation of mechanical excavators, and a proper ore-dressing plant, this waste does not occur and practically all the ore in a deposit is recovered. Some waste of finely divided ore occurs in the process of washing brown ores to remove the associated clay, and there is still room for improvement in operations of this kind. If it becomes necessary to mine material which is below the grade of present requirements, but which contains enough iron values to make it a possible ore in the future, such material is stacked so that it will be available at any future time. This policy has been most consistently followed in the Lake Superior district, and when such low-grade ores are required large amounts will be available merely at the cost of loading on the cars.

In the early days of iron making an appreciable part of the iron in the ores went into the slag and was permanently lost. Blast-furnace practice, however, has been so greatly improved in recent years that this source of waste is eliminated and practically all of the iron in the ore is now recovered.

PRODUCTION AND USE OF IRON ORES.

The beginning of the iron industry in America dates from 1645, when a furnace and forge were built at Lynn, in the province of Massachusetts Bay. In the century following a large number of small furnaces and bloomeries were operated in the New England colonies, using bog ores almost exclusively, and during this period Massachusetts was the chief iron producer. In 1734 the richer brown ores of western Connecticut and southern New York were opened and largely replaced the bog ores. The manufacture of iron was begun in eastern Pennsylvania in 1716, and a few years later in northern New Jersey, using the rich magnetites of that region. The industry had a rapid growth, notwithstanding the restriction placed upon it, and at the time of the Revolution there were over 140 furnaces and bloomeries in operation in this district.

In the fifty years preceding the Revolution a number of furnaces and forges were in operation in Maryland, Virginia, and the Carolinas, located for the most part on the tide-water streams of the coastal plain and using the brown ores associated in small quantities with the clays and sands of the coastal formations. The deposits of magnetite in the crystalline rocks of the Piedmont were also worked during this period to a slight extent.

After the close of the Revolution the iron industry expanded rapidly, following the westward progress of settlement, and had reached western Pennsylvania and the Appalachian Valley of Virginia and Tennessee before the close of the eighteenth century. In the first third of the nineteenth century it had reached as far west as Missouri and north to Michigan. During this period conditions favored a wide distribution of the industry. Charcoal was the only fuel used, and this could always be obtained in the immediate vicinity of the ores. Transportation facilities were very poor, and the small furnaces so situated as to supply the local demand, even working on inferior ores, could compete with the older establishments at a distance. About 1840 a revolution was effected in the iron-making industry by the introduction of anthracite and bituminous coal as a furnace fuel. The capacity of the furnaces was rapidly increased, and with improvement in transportation facilities the industry was concentrated at a relatively few points advantageously located with reference to the new fuel supply. Under the changed conditions the ore was brought to the fuel, hence only the best ore and the largest deposits were worked, and many districts, as Ohio and Kentucky, which had been heavy producers, were practically abandoned. With the decrease in average iron content of ores going into the furnaces, due to the depletion of the richest deposits, there is at present a notable tendency toward decentralization of the industry and a consequent reopening of abandoned ore deposits, though it will never revert to the conditions which prevailed during the charcoal period.

The statistics of iron production during the early years of the industry were not collected, and the total amount of iron ore consumed can not be determined. Not until 1889 were annual statistics of ore production collected, though they are available for the two preceding census years 1870 and 1880, and the annual production of intermediate years may be derived from the known production of pig iron as far back as 1870. Basing an estimate upon the average pig iron production shown for census years prior to 1870, the total iron ore produced from 1810 to 1869 was approximately 49,656,000 tons, and on the annual production of pig iron from 1870 to 1888 it was 153,758,000 tons. These amounts added to the 475,162,000 tons produced from 1889 to 1907 give a grand total of 678,576,000 tons produced since 1810. The amount produced during the Colonial and Revolutionary periods and up to the third census in 1810 is so small in comparison with the total production since that time as to be a negligible quantity.

In deducing the iron ore production from the production of pig iron, it should be borne in mind that a small proportion of this iron was made from imported ores and also that some pig iron is made from other materials than natural ores, as blue billy, zinc residues, rolling-mill cinder, scrap, etc. On the other hand, iron ore is used for other purposes, as in the manufacture of paint, as a fix or fettling in puddling furnaces, and as a flux in silver smelting, and the amount so used practically offsets the amount of material other than iron ore charged into the blast furnaces.

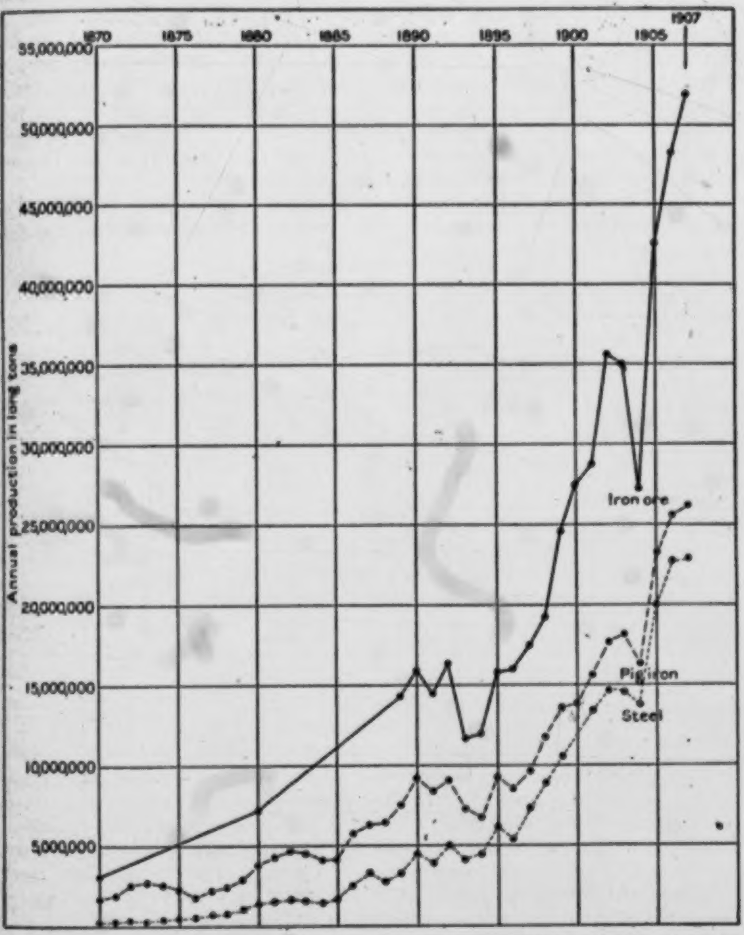

FIG. 1.—Curve showing the production of iron ore, pig iron, and steel in the United States, 1870–1907, in long tons.

The production of iron ore from 1870 to 1907, inclusive, is shown on the accompanying diagram along with the production of pig iron and steel for the same period.

The curve representing the production of pig iron shows more fluctuations than the ore curve, and that representing production of steel more than the pig-iron curve. In other words, the production of steel responds most promptly to varying industrial conditions. Thus the production of steel in 1907 shows practically no increase over 1906, while the rate of increase in ore is above the average for the preceding eighteen years. This is explained by the fact that the industrial depression of 1907 came so late in the year that it only slightly affected the output of iron ore, particularly in the Lake Superior district, where mining is more active in summer than in winter. It is practically certain, however, that the output of ore for 1908 will show a decided decrease similar to, and probably larger, than that which marked the years 1893–94 and 1904. The years 1892, 1902, and 1907 occupy maximum points in the curve, and each is followed by a decided drop and rapid recovery far beyond the preceding maximum. It may be safely predicted that the curve will resume its upward trend in 1909 after the drop of 1908.

The distribution of the production since 1889 among the varieties of ore enumerated in the chemical classification is shown in the following table:

Production of iron ores in the United States, by varieties, 1889–1907.

Year.	Magnetite.	Hematite.	Brown ore.	Carbonate.	Total.
	Long tons.	*Long tons.*	*Long tons.*	*Long tons.*	*Long tons.*
1889	2,506,415	9,056,288	2,523,087	432,251	14,518,041
1890	2,570,838	10,527,650	2,559,938	377,617	16,036,043
1891	2,317,108	9,327,398	2,757,564	189,108	14,591,178
1892	1,971,965	11,646,619	2,485,101	192,981	16,296,666
1893	1,330,886	8,272,637	1,849,272	134,834	11,587,629
1894	972,219	9,347,434	1,472,748	87,278	11,879,679
1895	1,268,222	12,513,995	2,102,358	73,039	15,957,614
1896	1,211,526	12,576,288	2,126,212	91,423	16,005,449
1897	1,059,479	14,413,318	1,961,954	83,295	17,518,046
1898	1,237,978	16,150,684	1,989,681	55,373	19,433,716
1899	1,727,430	20,004,399	2,869,785	81,559	24,683,173
1900	1,537,551	22,708,274	3,231,089	76,247	27,553,161
1901	1,813,076	24,006,025	3,016,715	51,663	28,887,479
1902	1,688,860	30,532,149	3,305,484	27,642	35,554,135
1903	1,575,422	30,328,654	3,080,399	34,833	35,019,308
1904	1,638,846	23,839,477	2,146,795	19,212	27,644,330
1905	2,390,417	37,567,055	2,546,662	21,999	42,526,133
1906	2,409,294	42,481,375	2,781,063	17,990	47,749,728
1907	2,679,067	46,060,486	2,957,477	23,589	51,720,619
Total	33,966,509	391,300,205	47,763,384	2,071,939	475,102,127
Percentage of totals for nineteen years	7.1	82.4	10.1	0.4	....
Percentage of total for 1907	5.2	89.1	5.7	....	....

The present relative importance of the several varieties is shown by the percentage and also the increasing importance of the hematite as compared with the other varieties. The combined total productions of brown ore and carbonate for the nineteen years is 2,000,000 tons less than the total production of all varieties for the year 1907.

The distribution of production for 1906 and 1907 among the six commercial districts is shown in the following table:

Production of iron ores in the United States, by commercial districts, in 1906 and 1907.

District.	1906.		1907.	
	Quantity.	Percentage of total.	Quantity.	Percentage of total.
	Long tons.		*Long tons.*	
1. Northeastern	2,582,666	5.40	2,822,822	5.45
2. Southeastern	6,208,140	13.00	6,197,360	12.00
3. Lake Superior	38,035,084	79.66	41,638,744	80.50
4. Mississippi Valley	117,570	.25	230,435	.45
5. Rocky Mountain	806,268	1.70	831,258	1.60
6. Pacific slope	(a)	....	(a)	....
Total	47,740,728	100.00	51,720,619	100.00

[a] The small production of California and Washington is included in the production of the Rocky Mountain district.

These figures indicate the commanding position of the Lake Superior district in the iron industry with 79.66 and 80.60 per cent of the total production for the two years.

DURATION OF THE IRON-ORE SUPPLY.

Predictions of the date of exhaustion of the iron-ore reserves involve a number of unknown factors, each of which adds to the uncertainty of the result. Among these factors the following may be mentioned:

1. The uncertainties of the estimates of reserves and the difficulty of fixing the ratio of the two classes have been fully explained in the sections devoted to the description of the ore deposits.

2. The extent to which imported ores will supplement the domestic supply can not be foretold, but it will be an increasingly important factor.

3. The extent to which the reserves will be increased by the discovery of new ore bodies can not be estimated, but it is highly improbable that all the important iron-ore deposits are now known.

4. The ores of the first class will not be entirely exhausted before utilization of the second class begins, and changing conditions, particularly of transportation and metallurgy, will continually shift the line dividing the two classes.

5. The stock of metal which can be reworked is constantly increasing and must eventually reduce the demand for metal obtained directly from the ores.

6. The substitution of other materials for metal now used for certain purposes, particularly for construction, will reduce the consumption to an extent which can not be even approximately estimated, and, on the other hand, the proportion of structures into which iron enters as an important constituent will undoubtedly increase.

7. The per capita consumption of iron ore has shown a rapid increase since the beginning of the iron industry. For 1907 and the four preceding census years it has been as follows: 1870, 180 pounds; 1880, 313 pounds; 1890, 560 pounds; 1900, 806 pounds; and 1907, 1,344 pounds.

8. The increasing cost of iron due to the increase in cost of fuel and the use of lower-grade ores requiring an increased amount of fuel per ton of iron smelted, will induce greater economy in the use of the metal; on the other hand, improvements in metallurgy will tend to secure a larger yield of metal for a given expenditure of fuel and power and may substitute low-grade fuel for the higher-grade coal now required in the blast furnace.

The most striking feature of the iron-ore production curve is the remarkable rate of increase shown in the period covered. Taking the production since 1870 by decades and estimating the last two years of the present decade, 1908 and 1909, the percentage rate of increase for each decade over the one preceding is shown in the following table:

Production of iron ore by decades and rate of increase.

Decade.	Quantity.	Percentage of increase.
	Long tons.	
1870-1879	43,770,527	....
1880-1889	91,043,854	108.0
1890-1899	163,989,193	80.1
1900-1909	[a] 392,000,000	138.0

[a] Approximate.

Each of the above decades, as shown by the production curve, contains a depression in which there was an actual decrease in production, so that they may be taken as fairly representing the tendency of the industry. These rates of increase are such that they do not permit the construction of a curve on which predictions for the future can be based. A comparison of the first and second rates, 108 and 80.1, would indicate a rapid decrease in the rate of increase, which, if continued, would have placed the date of maximum production about 1930. But a comparison of the second and third rates, 80.1 and 138, would indicate a rapid increase in the rate of increase. If the average rate of increase by decades, 108.7 per cent, should be continued, it would require the production in the next three decades of 6,088,000,000 tons. But the ore supply now available in the United States is estimated at 4,788,000,000 tons, which is only 78 per cent of the amount needed on this assumption. It is evident, therefore, that the present average rate of increase in production of high-grade ores can not continue even for the next thirty years, and that before 1940 the production must already have reached a maximum and begun to decline, and a very large use must be made of low-grade ores not now classed as available. The second condition, with its consequent greatly increased cost of iron, is the only thing which can prevent a decline in the iron industry, measured by the amount of pig iron produced, within the next thirty years, unless there is in the meantime very greatly increased importation of foreign ores.

In view of the many factors entering into the problem, the tendency of which is not always determinable, to say nothing of the weight that should be given them, any further prediction as to the date of exhaustion of the iron-ore supplies is so uncertain as to be wholly unprofitable and unwarranted.

RESOURCES OF THE UNITED STATES IN GOLD, SILVER, COPPER, LEAD, AND ZINC.

By W. Lindgren,
United States Geological Survey.

INTRODUCTION.

The ores of gold, silver, copper, lead, and zinc occur as a rule in localized deposits of varying form, depth, tenor, and geologic relations. There are no wide areas underlain by strata of ore with maintained characteristics. The ore deposits are exceptional occurrences. They are concentrated, it is true, in a number of localities, but the bodies are ordinarily of very irregular form, and it is difficult to predict what each new level in a shaft, each new drift on a level, will disclose. Some of the large companies mining copper, lead, or zinc ores have extensive reserves blocked out by actual development work or by borings, but the ore developed is rarely sufficient for more than a few years' work. The majority of the companies would undoubtedly decline to furnish detailed information on this subject.

The distribution of values is even more capricious in precious-metal mines than in base-metal mines, and in the case of gold the number of companies operating lode mines with large reserves can be counted on the fingers. Concerning deposits of gold-bearing gravels or placers, a somewhat more accurate statement can be made as to the probable extent of resources. These remarks serve to make clear the impossibility of ascertaining even the approximate extent of the total supply of metallic ores. The best that can be done is to forecast in a rough way the probabilities of the immediate future on the basis of the experience of the past. In doing so, it is well to bear in mind that many of the predictions ventured on this subject during the last fifty years by able men have proved very wide of the mark.

The conclusions reached in this report are based chiefly on investigations by the geologists of the United States Geological Survey.

MINERAL LANDS OF THE UNITED STATES.

The mineral-bearing lands still owned by the United States are largely confined to the Cordilleran States. The mineral lands of the Southern Appalachian States are privately owned, and as far as the total production is concerned they cut a small figure. Likewise, the copper-bearing lands of Michigan and the lead-zinc lands of Missouri and other States of the central valley have passed into private hands. There remain the States of Colorado, Wyoming, Montana, Idaho, Utah, Nevada, Washington, Oregon, and California, as well as the Territories of Alaska, Arizona, and New Mexico, in which there still exists a large aggregate area of mineral land belonging to the United States. The extent of the mineral land of the United States still owned by the Federal Government is an unknown quantity because (1) the mineral lands have never been segregated and surveyed, and (2) a very large acreage is simply held by assessment work, and the present laws do not require that such claims shall be surveyed or registered. It is true that the majority of claims on which valuable mines have been developed have passed to patent. But there are thousands, in fact, hundreds of thousands of claims on which mineral has been discovered, which are held by annual assessment work, and of which the General Land Office has no record whatever. Even many important producing mines, and practically all placer mines of Alaska, are thus held. This condition is made much worse by the fact that according to present laws anyone—individual or company—can locate an unlimited number of claims provided the assessment work is performed. As no assessment work is required until a year to two years after discovery, this rule works out so that a newly discovered camp is completely covered by locations by the first comers, and its growth may be seriously interfered with. In case of specially valuable discoveries the early arrivals are thus granted an unreasonable privilege which is always abused. The process is well known throughout the West, and is popularly known as "claim hogging."

The first steps toward ascertaining the area of mineral land still belonging to the United States would seem to be: (1) Survey and segregation of mineral lands; (2) registration of all mineral claims at the land office of the district.

Any estimates on the basis of available data are useless.

The first requirement, segregation of mineral lands, is no doubt easier to demand than to execute. There is no possibility, as with coal deposits, to segregate large areas with the confident knowledge that the mineral exists below them. For instance, a mountain range may present a favorable aspect from a geologic standpoint for the occurrence of metals, and yet no deposits may be found in it except perhaps within one limited area. However, the possibility always remains that some careful and deeper prospecting may reveal ores in the part hitherto considered barren.

A worse complication is involved when the land is valuable for several purposes. It may be good agricultural land; even if situated in the mountain regions it may, as is frequently the case in California, be valuable for horticulture and viticulture, or for pasture. Here is a conflict between permanent and temporary value. The land will always produce fruits, but the gold deposit below it will, in all probability, be exhausted in a limited time, very soon, indeed, in the case of many buried gravel channels. Such conflicts have caused much loss and annoyance in California. How can these two values be compared and measured?

A difficulty even more troublesome arises when the land is valuable for both its mineral and its forest. Here, however, we have to measure two more commensurate values, both of more temporary character than in case of agricultural lands. The value of the forest can usually be measured with some accuracy. The value of the mineral on the same land can usually not be measured with exactness. Very often the former will exceed the latter, as far as surface developments go, and then the question arises whether it is justifiable to interfere with free prospecting and search for metals in order to more effectively preserve the forests.

It would seem that the present interminable conflicts could be avoided only by a separation of the mineral and forest rights, while retaining for agricultural patents the right to possible later discoveries underneath the ground. The forest lands have great value, and as long as human nature remains what it is even the bona fide miner will continually attempt to gain possession of them by unduly extending his mineral locations. Many mining districts are covered with a scant growth of forest, barely enough for the miner's needs for timber and fuel. Such lands should not be classified as forests.

WASTE.

The prevention of waste in mining and reduction processes is a most important subject. Whatever our views of future necessities, it is clearly not right to carelessly waste the metallic treasures of the earth, and in this direction much can be accomplished. The loss is rather in processes of concentration and reduction than in mining. In some cases pillars of ore are left, but the shape of the deposits is generally such that all the ore can be extracted without much loss. In industries like copper mining, where the term "ore" has rapidly changed its meaning within the last decade—where, in other words, ore containing 1, 2, or 3 per cent of copper can now be mined profitably where it was formerly considered waste—it is clear that large bodies must be left now which later may possibly be extracted with profit. But this ore is, of course, not lost unless the whole mine goes to wreck.

In concentrating and milling the greatest losses occur and the percentage of these is largest in the low-grade deposits. In the earlier days of gold and silver milling enormous amounts of rich tailings were sent down the creeks and gulches and permanently lost, largely because of conviction that the values could not be recovered, partly perhaps because of disinclination to let it be known that the tailings contained any values. Matters have changed in this respect, and tailings are now generally stored with a view to possible reworking. No doubt the States could aid this practice of economy by legal requirement of such storage, a policy which besides is desirable in order to avoid contamination of the water supply.

The losses of gold, silver, copper, and lead in smelting are generally not large, and, moreover, the slag is necessarily and easily stored. In many cases the slags of earlier years have been worked over. By far the greatest losses take place in the concentration of copper, lead, and zinc ores. They probably reach their maximum in zinc ores or in copper ores with soft metallic minerals like chalcocite, and here often attain 30 per cent or even 40 per cent. These operations are also conducted on a large scale, making storage of tailings difficult, but the same principle should be applied by legal requirements wherever possible. Somewhat better conditions now prevail in Missouri than formerly, but some years ago it was not at all uncommon to have losses in zinc concentration reaching 40 per cent.

No doubt it will be impracticable, under our system of government, to compel mine owners to prevent unnecessary waste by prescribing certain working methods. Probably no European state has ever gone so far. Storage of tailings will probably prove to be the best remedy if it can be legally enforced.

It is perhaps in the utilization of by-products that we have most to learn, but the standpoint is naturally taken by miners and smelting men that if it can not be done with profit it had better not be done at all. I refer specially to the smelter fumes and to the extremely large quantities of sulphur and arsenic that are driven off in the air, sometimes with great damage to the surrounding agricultural districts. The case of arsenic is especially interesting. The statement is made by F. L. Hess[a] that—

> Enormous quantities of arsenic in fumes continually escape from the smelters of the country, while at present comparatively little arsenic is saved. Harkins and Swain (Jour. Am. Chem. Soc., vol. 19, 1907, pp. 970–998) state that in August, 1905 (when the experiments were made), from the Washoe smelter, which works exclusively upon Butte copper ores, 59,270 pounds of arsenic trioxide per day were passing through the stack. This is equivalent to 10,817 short tons per year, and is exclusive of what arsenic trioxide was saved from the flues. At 5 cents per pound, the lowest price for which white arsenic sold in 1907, this waste product of one year would be valued at $1,081,700. The waste arsenical fumes at this plant alone amount to more than six times the domestic saving of arsenic trioxide, and to much more than the combined production and imports of arsenic in the United States each year.
>
> At the Butte reduction works and the Great Falls smelter other great quantities of more or less arsenical Butte copper ores are treated, from which no saving of arsenic is known to have been made, and from which the losses must be very great.
>
> In Utah both the Bingham and the Tintic copper ores are arsenical, and no saving has yet been made from them, though immense quantities of ore are smelted.
>
> It is recognized that in handling a low-priced product like arsenic, saving can not be carried to extreme refinement without becoming unprofitable. However, arsenic is now being extracted from sulphuric acid at a number of establishments in England, and both products are cheap articles. If even one-half of the arsenic wasted were saved, the market in this country would be glutted. However, without taking account of the possibility of greater demand, if there were a greater supply at a somewhat lower price, there will in time probably be some plan devised for the better saving of smelter fumes, through the operation of which it will be unnecessary for this country to import arsenic while so much is continually being wasted.

Smelter fumes occupy a similar position to tailings in mills, but they can not, of course, be stored. On the contrary, they spread over the country, frequently damaging the vegetation near the smelter, and the compulsory saving of the sulphur and arsenic contained will probably soon, in most cases, be required by law.

In many cases the waste in mining and milling is the result of ignorance. Dissemination of knowledge and investigation of methods by bureaus of the Federal Government and the States will do much to check the waste.

GENERAL CONCLUSIONS.

The individual reports on the separate metals will show that the resources in each case are very large, but that they can not (with few exceptions) be measured with any accuracy. To give definite figures representing our metal supply is quite out of the question. It will be shown that our resources of silver, copper, and zinc are very large and that a moderate rate of increase in production can be maintained probably for the next twenty years at least. In case of lead it is not probable that the production can be very greatly increased. While it is true that, with a continuation of the present increasing rate of production, the known reserves, workable under present conditions, will be exhausted before the middle of the present century, this prediction should not be announced without important qualifying clauses. The nature of the case prevents a full knowledge of our resources. They are developed by mining operations only, and exploration does not materially anticipate unusual demand. Ten years ago a review of our metallic wealth would have revealed a far greater shortage in the supply of metals than is now believed to exist, and it is probable that, in case of some metals at least, ten years from now our resources will be known to be greater than they are at present. The higher grade of ores of copper and lead are growing scarce, but improvements in technologic processes, by lowering the cost of reduction, have added great quantities of lower-grade material to our available ore supply, and will probably continue to do so. With increasing demands quantities of old metals will be returned to use. The importance of this factor is great, but it is difficult to measure. In case of gold it does not seem likely that, on the basis of present developments and processes, our production can be made to greatly exceed $110,000,000 per annum for the next twenty years. And on the same basis it would seem likely that after some such period the gold production would gradually decrease.

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[a] Mineral Resources, U. S., for 1907, separate on "Antimony and arsenic," p. 9.

If we were sure that the development of the world would proceed indefinitely on the same lines as those of to-day; that metals would have the same value; that the same metals would be used for the same purposes; then it might be possible (to use an expression of Professor De Launay[a]) "to strike a balance between us and our descendants." We have not this knowledge. We may forecast what is likely to happen and what our needs will be in the metal industry, for the next ten, twenty, possibly fifty years. The conditions and developments in the more distant future are completely beyond us.

It is reasonably certain that the industrial development of the world will continue on an ever increasing scale. But who can tell us what methods and materials will be used, and what new discoveries in little explored continents will disclose? Substances now eagerly sought may then be of little value; reserves established by the States may be useless and simply serve to restrict the present development. Legislative interference with production of metals is likely to be futile and probably can not in the long run successfully interfere with the operation of economic principles based on laws of supply and demand.

GOLD.

PRODUCTION OF THE UNITED STATES.

Since 1892 the gold production of the United States has increased at a very rapid rate. An output of $60,000,000 was recorded in 1852 and 1854, shortly after the discovery of the California placers. From that time the production decreased gradually to $30,000,000 in 1883 and 1884 and then rose slightly, remaining at about $33,000,000 from 1885 to 1892. The effect of the Cripple Creek discoveries and of the application of the cyanide process became apparent after 1892 and the production steadily mounted to about $80,000,000 in 1902. A serious falling off in Colorado reduced the total in 1903 to $73,500,000, but during the next four years in consequence of the discoveries in Alaska and the development of the dredging industry in California, there was a renewed rise which culminated in a production of over $94,000,000 in 1906.

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[a] De Launay, L., La conquête minérale, Paris, 1908, p. 379 et seq.

In 1907 the output fell to $90,400,000, but a further decline is not probable for 1908. The causes of the decrease in 1907 were the generally disturbed financial conditions, labor troubles, and a scarcity of water in Alaska.

The output of the United States is shown in the accompanying diagram.

PRODUCTION OF THE WORLD.

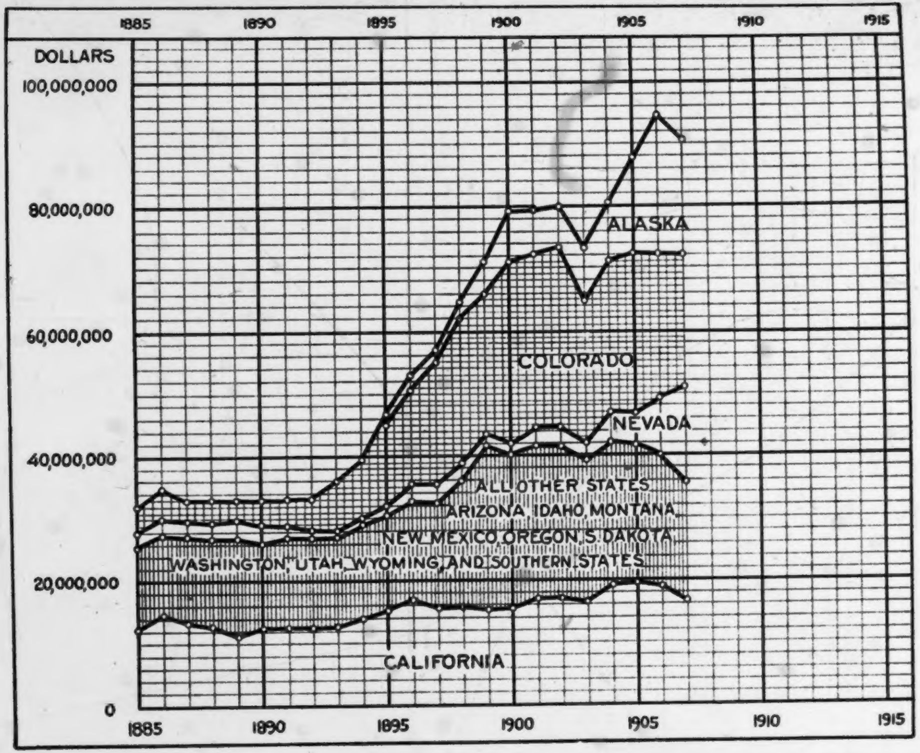
The rapid increase in the annual production of gold of the world is a feature which has been the subject of much discussion in its relation to the monetary systems and financial affairs generally. The facts are best brought out in the accompanying diagram. California and Australia in the early fifties brought the production rapidly to $180,000,000 from about $10,000,000 in 1830. The output in the earlier part of the century was largely derived from Russia. The gradual decay of placer mining in California and Australia reduced the yield for the world to nearly $100,000,000 about 1886. In the period from 1885 to 1890 numerous discoveries in South Africa, in Western Australia, and in Colorado changed the aspect of the industry.

The cyanide process, which gave better extraction at reduced cost, was introduced about this time. In South Africa especially this process has proved of the utmost importance. A little later discoveries were made in Alaska, Nevada, the Canadian Yukon, Mexico, Rhodesia, and West Africa, notwithstanding the assertion made by many that no further important supplies of gold were likely to be found.

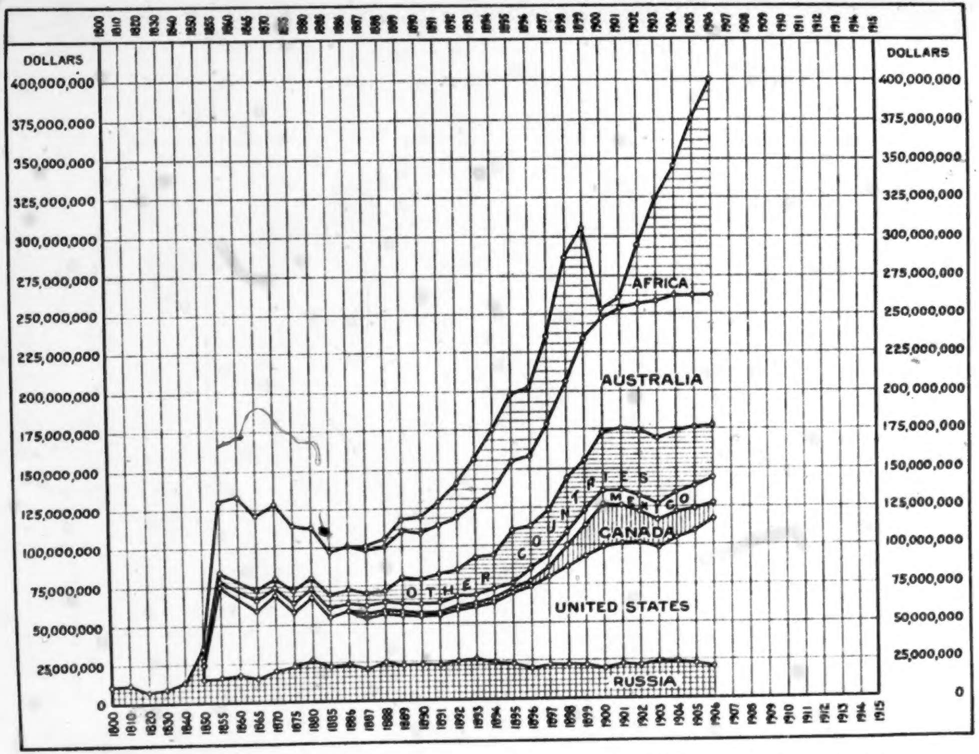
Thus, since 1887 the production of the world has been trending upward, except for the temporary decline due to the Boer war, and in 1907 was about $412,000,000. It will be observed that Africa now (1907) contributes about $151,000,000, or one-third of the world's production, and of the African output about $133,000,000 comes from a small district in the Transvaal.

Barring new and unexpected discoveries it is believed that the world's production will not increase hereafter at the recent rapid rate of advance. It is believed that the maximum production has nearly been reached in the Transvaal, although the present output can be maintained for a long time, probably for more than thirty years. The output of Australia from present indications is more apt to decline than to increase.

As indicated by the diagram, the production of Russia forms a solid and constant substratum on the permanence of which it is fair to rely. A continued increase in the United States is scarcely to be expected, although the recent history of gold mining in Nevada



THE PRODUCTION OF GOLD OF THE UNITED STATES AND OF THE PRINCIPAL STATES AND TERRITORIES FROM 1885 TO 1907.



THE PRODUCTION OF GOLD OF THE WORLD AND OF THE PRINCIPAL COUNTRIES FROM 1800 TO 1906.

(After E. Biedermann.)

shows what unsuspected riches may lie for decades within easy reach. It is true that there are large unprospected territories in South America which with developing lines of communication may produce much gold, but on the whole the probabilities of the immediate future are rather in favor of maintenance of the present level of output than of a further sensational advance.

RESOURCES OF THE UNITED STATES.

The diagram shows that the production of the United States can, for present purposes, be divided into five parts. In 1907 Colorado, Alaska, California, and Nevada in the rank indicated contributed each from $15,000,000 to $20,000,000 to the total output. The remaining fifth part, approximately $19,000,000, came from Utah, South Dakota, Montana, Arizona, Idaho, and Oregon, the amount from the remaining States (southern Appalachian region, New Mexico, Washington, and Wyoming) being negligible.

IDAHO AND OREGON.

Great constancy has been shown by Idaho and Oregon in their gold output, which for each State generally is below $2,000,000 per annum and may be expected to continue on the same basis for many years to come. The product is from placers and gold-quartz veins.

SOUTH DAKOTA.

In South Dakota the output has varied since 1889 from $3,000,000 to $7,000,000. Of this about $5,000,000 is derived from the Homestake mine, the most productive gold mine in the United States. The total yield of this mine approaches $60,000,000. A large tonnage of low-grade ore (about 1,400,000 tons per annum) is treated in a mill with 1,000 stamps. The deposit, as far as known, does not approach exhaustion; the shafts have not attained great depth. The blanket deposits in limestone may be exhausted at an earlier date than the Homestake, though the reserves appear to be fairly large. It is likely that South Dakota will be able to maintain its production for a long time.

ARIZONA.

Arizona has for many years supplied from $1,000,000 to $3,000,000, which is derived about equally from the copper ores of United Verde, Globe, and Bisbee on one hand, and the gold-quartz mines of Yavapai, Mohave, and Yuma counties on the other hand. From neither source is much falling off to be expected for the next ten years; a moderate increase is more probable.

MONTANA.

Montana has long maintained a steady gold production ranging from $3,000,000 to $4,000,000. For some years $1,000,000 has been derived from the Butte copper ores, and an equal amount from cyaniding the quartzose ores of Fergus County. The latter supply, however, has recently shown a sharp decline. The balance of the

State total has come from a great number of small gold and silver mines in several counties. It is not likely that the production of Montana in the near future will sink below $3,000,000.

CALIFORNIA.

The California production is notable for its constancy. Since 1885 the State has annually supplied from $12,000,000 to $19,000,000 in gold. The rise noted in the diagram during the last few years is largely due to the development of the dredging industry. In 1907 the State produced $16,900,000, which, disregarding some minor sources, may be divided as follows: Quartz mines, $9,400,000; copper mines, $350,000; placer mines, $6,800,000. The production from quartz mines has of late decreased, but it may be relied upon to continue, with fluctuations, for a long period. There are few very large mines, but there are many which have shown ability to maintain moderate production for many years past. Few of the mines have ore developed for more than two or three years, and even approximate figures as to future reserves are out of the question. On the other hand, a long-continued and steady output gives assurance of a continuance for a long period of years, with probable ultimate diminution. The gold from copper ores will increase, and may in a few years reach $1,000,000.

The placer-mining industry of California presents some interesting features. For many years the production from this source gradually decreased. This was largely due to the prohibition of hydraulic mining in the drainage areas of Feather, Bear, Yuba, and American rivers on account of the damage done to farming lands and to the harbor of San Francisco.

In the last ten years gold dredging has been developed to a high degree in consequence of the improvements in dredge construction and of the discovery that a large area near the mouths of the rivers flowing from the gold-bearing region of the Sierra Nevada is available for such mining. The output from the dredges in 1907 was somewhat over $5,000,000. Very sanguine predictions have been made as to the amount of land available for dredging in California and in the Rocky Mountain States, and to some degree they are justified. The fact remains, however, that the production of the Rocky Mountain States from dredging is as yet very small (about $300,000 in 1907), and it is believed that there are no extensive areas which at all compare with those at the base of the Sierra Nevada. It is estimated by the most competent authorities that the known dredging lands in the great valley of California amount to 18,000 acres. If an average depth of 45 feet, corresponding to 72,600 cubic yards of gravel per acre, and an average content of 12 cents per cubic yard, or $8,712 per acre, be assumed, then 18,000 acres would ultimately yield $156,800,000. Up to 1905 about 700 acres had been worked. This crude estimate may be considerably off the mark, but it serves to show that a large amount of gold is contained in the dredging lands, and that the industry will be of great importance for the next quarter century at least. The total dredge production of California since 1900 is about $18,000,000.

It has been stated that the production of the placer mines, outside of the dredges, has receded pretty steadily for many years, and that this is due to the practical prohibition of hydraulic mining in the basins of the principal rivers draining into the great valley. The gold reserves in these gravels are undoubtedly very large. Were these mines allowed to operate, several million dollars per annum could undoubtedly be added to the California production. Estimates by the United States engineer officers indicate that in the basins of the Yuba, American, and Bear rivers 1,500,000,000 cubic yards of gold-bearing gravel would ultimately be available by expensive development work, consisting in tunnels, ditches, etc., the amount at present available being about 500,000,000 yards. Adding to this estimate 100,000,000 cubic yards for the Feather River and the southern rivers draining into the San Joaquin, we would have 1,600,000,000 cubic yards, much of which is poor, but which may be assumed to average 6 cents per cubic yard.

According to this rough estimate nearly $100,000,000 in gold would be available if the hydraulic mines of the central gold region were permitted to work. Siskiyou and Trinity counties now yield $600,000 per annum from their hydraulic mines. The extent of the reserves in these counties is less well known, but they are believed to be large.

No State or Territory (except Alaska) compares with California as to the probable extent of gold reserves. There is reason to believe that California can maintain a production of $15,000,000 per annum for the next fifty years, and that then it probably would not be exhausted. Ultimately, of course, the gold reserves would become smaller, as has been the experience of the European countries in which gold mining once flourished. Eventually the gravels will be worked out, the dredging ground exhausted, the quartz mines impoverished or difficult to work on account of increased expense at depth. But this is looking far into the future. What the accompanying industrial conditions will then be is beyond our ken.

ALASKA.[a]

Though recently discovered, the mineral resources of Alaska have proved to be enormous. The total production of gold has risen rapidly and almost continuously since 1890. It reached $21,400,000 in 1906, but fell to $18,500,000 in 1907, and may decline somewhat further in 1908. This recession is, however, only temporary, for it is believed that the resources in placer gold are very large. The total gold output of Alaska since 1880 is about $122,000,000. Of this about $25,000,000 was produced from quartz mines in southeastern Alaska, which annually yield about $3,000,000. The Treadwell Island group of mines is the principal factor, with an ore production of 1,400,000 tons per annun and a recovery of about $2.50 per ton. The deposit can be compared only to that of the Homestake mine in South Dakota, and, so far as known, the ore body shows no contraction or serious diminution of tenor in depth. The greatest depth now attained is 1,650 feet. Probably no obstacles to mining at far greater depths will be encountered, and the present production seems assured for many years. There are other important quartz mines in process of development.

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[a] A more detailed report on the Territory will be contributed by Mr. A. H. Brooks, of the Alaska division of the U. S. Geological Survey.

The placer fields of Alaska are chiefly in the Yukon basin and in Seward Peninsula. Mr. A. H. Brooks has shown that in the latter region the gravels contain a total of about $300,000,000. There is probably as much in the Tanana (Fairbanks) and Yukon basins and the largest part of this will probably be extracted by dredging. With better communications and with the development of technical methods, gravels of lower grade can be worked, although the lowest grade of material possible to handle must remain very much higher than for corresponding gravels in California. While in the latter State 10 cents per cubic yard will yield a profit, 50 cents will probably be the lowest limit for some time to come in Alaska, where steam thawing must be resorted to as a rule.

The copper deposits will add a certain, though not very large, amount to the gold production and it is not impossible that workable gold-quartz mines will be discovered in Seward Peninsula and on the Yukon.

As far as visible supplies are concerned Alaska stands easily first in the United States and will yield a large annual production of gold for a long period of years.

COLORADO.

Until 1892 Colorado was of comparatively small importance as a gold producer. From three to four million dollars were contributed with great regularity from the Gilpin-Clear Creek field and the San Juan region. The former field continues its production steadily with few changes; the depth attained is comparatively small and a continued yield of about $2,000,000 may be expected for an indefinite time. The San Juan region came into prominence some fifteen years ago with the development of the Telluride, Ouray, and Silverton mines and now yields annually $5,000,000 to $6,000,000. Some mines bid fair to continue for many years; others show signs of exhaustion, but the region has great possibilities and a long-continued production may be expected. In most cases reserves of "developed" or "probable" ore are not large. One prominent gold mine in this region now has reserves for two years in sight; but few have more and many have less.

The unexpected discovery and development of the Cripple Creek district in 1890 brought Colorado to the front as a gold-producing State and rapidly increased the State's output from an average of $4,000,000 to nearly $29,000,000 in 1900. In 1907 the gold production of Colorado was about $21,000,000. The new district proved extremely rich, but the largest ore bodies have now been worked out down to the depth of the lowest drainage tunnel. The quantity of ore above that tunnel has been enormous. Including 1907, Cripple Creek has produced $179,000,000. The maximum production of $18,000,000 was reached in 1900. In 1907 the output was $11,000,000. The future of Cripple Creek is largely dependent upon the character of the veins below the present tunnel level. A new tunnel 700 feet below the present drainage level is now being driven, but it will be at least two years before it will have reached the producing area. It is believed that the deposits will be less rich at greater depths, but the tunnel is likely to open many important ore bodies and its completion should be followed by an increase in the output, which may be maintained for many years. But it should be steadily borne in mind that this is only a probability. We know little about the conditions or the size of the ore shoots below the bottoms of the present shafts.

The conditions in Colorado are very different from those in California and Alaska. There are few extensive gravel beds which may be confidently predicted to yield millions of dollars. Basing an opinion as to the output of the future simply on the records of the past, one may say that the State will probably be able to maintain a production of $15,000,000 to $18,000,000 for a long period, and that the ultimate exhaustion of its lode mines is probably far distant.

NEVADA.

The gold-mining industry of Nevada has been characterized by sudden outbursts of high production followed by periods of depression. The bonanzas of gold and silver ores of the Comstock, Eureka, Tuscarora, and Pioche in the seventies were rapidly exhausted; then followed two decades from 1883 to 1903 of small gold production ranging from $1,000,000 up toward $4,000,000. The discovery of Tonopah and Goldfield brought another sudden rise in production, and in 1907 it attained $15,000,000, of which $11,000,000 was derived from the two new gold camps. The State has been very extensively prospected during the last eight years, and many new camps have been discovered, which, with improvement of methods and communications, will add their quota to its output.

To this State applies in a still higher degree what has been said about Colorado. The known reserves of ore are generally small, while their grade is high. One important mining corporation states in its report that it has reserves of about $8,000,000 in value, but this is exceptional. Other mines now producing will probably be exhausted in a short time. On the whole, however, it is likely that the aggregate output from the many mining camps already discovered will be sufficient to keep the production of the next ten years at least close to the $10,000,000 mark.

The copper mines of Ely will soon afford a steady yield of $300,000 to $500,000 per annum in gold as a by-product. Discoveries of deposits of great importance are always possible in Nevada.

CONCLUSIONS.

In the preceding paragraphs it has been shown that the reserves in gold of the United States are great, but that they can not be appraised with anything approaching exactness. Only in case of the placers is a rough estimate possible. It has been shown that the resources in placer gold are chiefly in Alaska and California. Based on present methods of working and present wages the recoverable amount of gold in these placers would perhaps approximate $1,000,000,000. The other States have also resources in placer gold, but they are of importance only in Montana, Idaho, and Oregon, and even in these States they are small compared to Alaska and California.

The placer gold won in the United States in 1907 amounted to about $24,000,000, and it is believed that this quantity can be supplied for a long succession of years. Ultimately the placers will be exhausted.

The amount of gold derived from copper ores in 1907 was only about $5,500,000, but this represents a stable and even increasing quantity which is to be relied upon at least for the next quarter century and most likely much longer. The gold derived from lead ores is much less (only about $2,100,000), and will probably slowly decrease for the next ten or twenty years.

From quartzose gold and silver ores $55,000,000 was recovered in 1907. No calculation can be made as to total reserves available, and the figures, could they be collected, would be of little use. Mines will be exhausted, but new ones are coming in. Ore shoots are worked out, but others are found. Most of the mining districts have as yet attained only a very moderate depth, and it may be said that the resources of siliceous gold ores are very far from being exhausted. Just how long they will last nobody can tell. In a general way ore deposits are more likely to decrease than increase in richness as depth is attained, and at the same time the operating costs are likely to become higher. It would seem that this ultimate decline is rather far off at the present time. Certain parts of the western country, particularly Nevada, Washington, and Idaho, still suffer from inadequate railroad communication, and each new line as a rule leads to the opening of a number of deposits which previously were unprofitable.

New discoveries are always possible and in some regions are probable. Methods of working are steadily improved.

Unless very important new discoveries are made it is thought unlikely that the production of gold in the United States will rise much above $110,000,000. Nor is it likely that it will sink below $60,000,000 within a long period of years.

The gold-bearing gravels and the dredging lands of California and other Cordilleran States have long ago passed into private hands. Only in Alaska are there any considerable amounts of such public lands left. It is believed that it would be in the highest degree inadvisable to withdraw from location any part of the placer lands of the public domain.

Regarding lode mines it must be remembered that land classed as mineral and part of the public domain may or may not be valuable. The value can, as a rule, be esablished only by expensive prospecting operations. To withdraw such mineral lands or to put a royalty on the product would be unwise.

WASTE.

There is comparatively little waste in the mining of gold ores. In the concentration of base ores the loss of gold is large, probably 30 per cent, but there is a relatively small amount of gold involved. In the usual combined process of amalgamation and concentration followed by cyaniding or in chlorination the loss is small; the recovery is generally about 90 per cent. In the recovery by smelting the loss of gold is extremely small and practically all of it is collected in lead or in copper matte. In electrolytic refining of copper and lead the loss is negligible.

At the same time it would be advisable to make storage of mill tailings compulsory. The reworking is sometimes profitable and can be done at little expense.

Much has been said about the loss in placer mining and in hasty operations in rich ground, as in Alaska; this is undoubtedly heavy, as attested by the repeated working of such ground. Even in better constructed plants there is some loss of fine gold, but the recovery is probably 95 per cent. In plants of the best kind, for instance hydraulic installations with undercurrents or dredges with the most improved appliances, the recovery may be considerably higher. It should be added, however, that few exact data concerning these losses are available.

CONSUMPTION.

The consumption of gold in the United States approximately equals the production; at least this appears to be true for the last thirty-five years.

In 1906, according to the Director of the Mint, the quantity of gold used in the arts, exclusive of gold coin and old material, had a value of about $29,000,000. (Total amount used in the arts, $39,000,000.) The quantity used has doubled since 1900. In 1906 gold was coined to the amount of about $79,000,000.[a] The total gold used for coinage and the arts in the United States in 1906 had thus a value of $108,000,000, or $14,000,000 more than the domestic product. The records show that a balance of $109,000,000 was imported during the same year, so that for 1906 $203,000,000 would represent the consumption of gold in the United States. The amount imported in 1907 was, however, unusually large.

For the period 1901–1905, according to Mr. Biedermann's[b] figures, the addition to the gold stock of the United States was $412,000,000, and this figure is $8,000,000 less than the domestic production for the five years. According to this the United States retained practically all of the gold produced within its territory for this time.

The total metallic stock of gold held in the United States on December 31, 1906, was, according to the estimate of the Director of the Mint, about $1,600,000,000. The production of the United States since 1873 is $1,650,000,000.

The total stock of gold coins in the world in 1905 was $8,050,000,000. Adding to this $2,000,000,000 as the probable amount used in the arts, we have a total of $10,000,000,000. Against this the total gold production of the world since 1860, according to the Director of the Mint, is $7,652,000,000.

The gold production of the world for the five-year period, 1901–1905, amounts to about $1,688,000,000.[c] This has ultimately been divided between the nations as follows: United States, $412,000,000; France, $378,000,000; Germany, $242,000,000; India, $177,000,000; Great Britain and Austria, each $112,000,000.

The flow of gold to India and Egypt has often been emphasized in the press. No doubt such importations are manufactured into jewelry or are hoarded and are permanently lost to commerce and industry. The above figures will show, however, that such hoarding has not caused the great demand for gold during recent years. The real cause is the heavy absorption of the metal by the commercial nations in order to fortify their monetary position. The introduction of the gold standard has forced those great nations to create large gold reserves. This process has been going on for the last twenty years, but from now on the demand for gold for this purpose will probably slacken.

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[a] Probably $6,000,000 of this consisted of mutilated domestic coins and scrap.

[b] Biedermann, E., Die Statistik der Edelmetalle, etc.: Zeitschr. Berg, Hütten u. Salinened wesen, Bd. 56, Heft 1, Berlin, 1908.

[c] Biedermann, E., op. cit.

SILVER.

PRODUCTION OF THE UNITED STATES.

The silver production of the United States became of importance about 1860 and increased rapidly up to 1892, when it attained 63,500,000 fine ounces. The decline in the price had begun in 1875, and in the year of maximum output the price had fallen to 88 cents per fine ounce. Since 1892 the yield of silver has remained practically constant, averaging about 55,000,000 ounces. In 1907 it was 56,500,000 ounces, but the present year will witness a considerable decline. The lowest price of silver was about 47 cents, in 1902. The price rose to 70 cents in 1907, but has again declined to 50 cents, in October, 1908. The general result has been that a great number of mines which extracted silver ores have closed down, but the compensating factor that an increasing quantity has been obtained as a by-product from lead and copper ores has kept the output steady. The lower line in the diagram shows the course of the production of the metal in the United States.

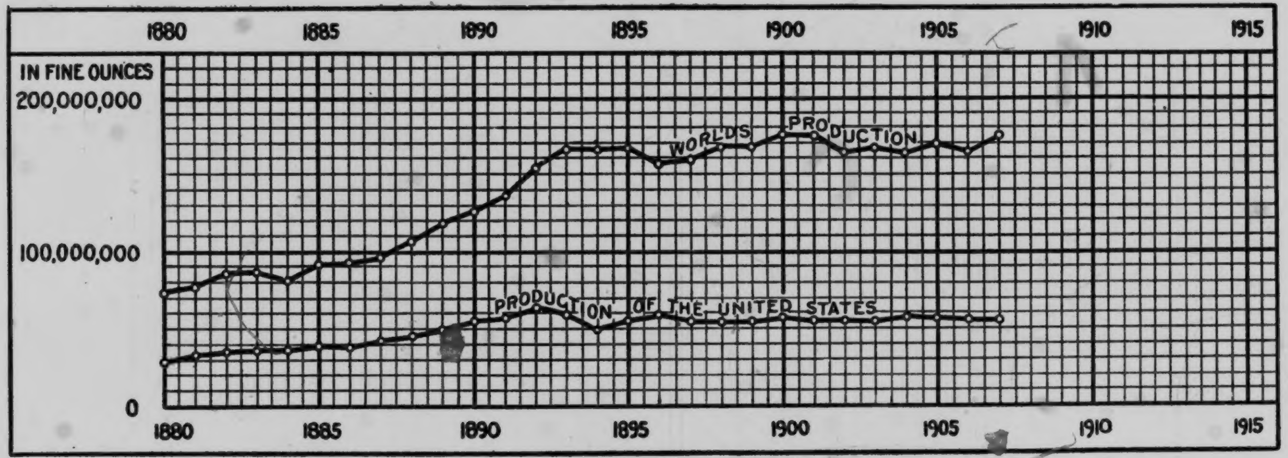
PRODUCTION OF THE WORLD.

The world's production of silver was 92,000,000 ounces in 1885, and about 178,000,000 ounces in 1907. The upper line in the diagram represents the world's production in the same time, and it well illustrates the constancy of the supply. The United States and Mexico are the most important contributors to the production of the world, the supply from each source being from 55,000,000 to 65,000,000 ounces. The rehabilitation of the mining industry of Mexico, which has taken place in the last twenty years, has gradually increased its output to more than double that of 1885. The remaining third of the world's production is mainly derived from New South Wales, Germany, Peru, and Bolivia. In many countries the output of silver is receding, owing to low price and difficulty of competing with the United States. To offset this, the silver output of Canada has lately been increasing at a rapid rate, and in 1907 attained nearly 20,000,000 ounces.

RESOURCES OF THE UNITED STATES.

The silver-producing States had in 1907 the following rank: Colorado, Montana, and Utah, each producing slightly over 11,000,000 fine ounces; Nevada and Idaho, each yielding about 8,000,000 ounces; Arizona, 3,000,000 ounces; and California, 1,500,000 ounces. None of the remaining States produced over 600,000 ounces.

An analysis of the statistics of 1906 is published in Bulletin 340 of the United States Geological Survey. From this it appears that the total output, disregarding the small amount of silver obtained from placer gold, was derived as follows: From lead, copper, and zinc ores, 40,100,000 fine ounces; from quartzose gold and silver ores,



THE PRODUCTION OF SILVER OF THE WORLD AND OF THE UNITED STATES FROM 1880 TO 1907 (IN FINE OUNCES).

16,500,000 ounces. A large proportion of the base-metal ores contained only a small amount of silver, which might be properly regarded as a by-product. Quartzose gold ores also contain silver which is recovered as a by-product and from this source 4,000,000 ounces were obtained in 1906, making one-quarter of the total from quartzite ores.

Looking at the question from another standpoint, it was found that from ores which carry predominating silver values, and which thus may be classed as silver ores, 19,500,000 fine ounces of silver were obtained. This is somewhat more than one-third of the total output of 56,500,000 ounces. It must be taken into consideration, however, that at least one-half of these ores could be profitably mined only because other metals besides silver were present. Only 1,500,000 ounces were obtained from ores containing no other recoverable metals.

From these data the present small importance of silver mining as a distinct and separate industry is clearly perceived. The pure silver ores are not scarce, but at the present price of the metal they can not be profitably treated unless containing at least about 20 ounces per ton. The lead ores of the Rocky Mountain region are as a rule richer in silver than the copper ores. In the lead ores of the Mississippi Valley silver is either absent or contained in extremely small quantities. Should the quantity of lead ores mined in Colorado and Utah gradually diminish, which seems probable, a corresponding diminution of the silver supply would follow. On the other hand, copper will probably for many years be mined on an increasing scale, and although the copper ores are poor in silver, the great tonnage handled will add much silver to our annual output and compensate for the possible loss from the decrease in the supply of lead ores. The zinc ores do not contain much silver; those of southwestern Missouri are free from silver, and the Rocky Mountain ores rarely contain more than a few ounces per ton.

From all this it is evident that the present supply of silver is assured as long as the mining of lead and copper ores, as well as of quartzose gold ores, continues on the present scale. Should there ever be a scarcity of silver, with accompanying rising price, the Rocky Mountain region beyond doubt contains a large supply of quartzose low-grade silver ores which could be profitably extracted with silver above 70 or 80 cents per ounce.

CONSUMPTION.

The United States consumes only a part of the silver produced. The domestic consumption is divided between coinage and industrial uses for the manufactures and arts. The demands for the latter use have doubled since 1898, and at present the amount consumed is 20,000,000 ounces, of which about 4,000,000 ounces represent old material remelted. For coinage the mints consume variable amounts ranging, during the last ten years, from 4,500,000 ounces to 23,000,000 ounces. In 1906, 7,700,000 fine ounces were coined. The total domestic consumption of the yearly product of the mines may be placed at 25,000,000 ounces. The remainder, about 32,000,000 ounces, is exported As is well known, the larger part of the export is taken by India and China. The demand by India is in the aggregate an enormous sum and is increasing at a rapid rate. For 1906–7 the total imports of silver by India were over 118,000,000 ounces, an increase of 34,000,000 ounces over 1905–6. On the other hand, the generally much smaller demand from China fell off, and during 1906 that country actually exported silver. The larger part of the silver which goes to India is, as well known, permanently lost to our industrial world by hoarding. Since the Indian government has succeeded in establishing the permanent value of the rupee at 16 pence (on basis of 1:21.85) it is likely that the decline in price of silver will be checked, but the supply appears to be so great that a vigorous recovery can hardly be expected.

COPPER.[a]

PRODUCTION OF THE UNITED STATES.

The copper-mining industry of the United States has developed at a rapid rate. In 1888 the production was 226,000,000 pounds of the metal. After eight years, in 1896, it had doubled. After ten years again, in 1906, it had nearly quadrupled, attaining almost 918,000,000 pounds. Reactionary tendencies developed in 1907 and 1908, and the output of the latter year will probably be about 860,000,000 pounds. It is impossible to accurately forecast the final character of the curve of production, but if we draw a straight line from the point on the diagram representing the production of 1883 to that of 1908, we shall with some probability have the trend of the production for future years. It is altogether improbable that the increase will continue at an increasing rate; more likely the rate will gradually diminish; a straight line will probably express its trend for the next ten years, at least. On this basis the production would be about 900,000,000 pounds in 1910, and 1,160,000,000 pounds in 1920. The following table will give a good idea of the growth of the industry since 1845. It shows that the rate of increase during the present decade is considerably smaller than it was during the decades 1881–1890 and 1891–1900:

Magnitude and growth of copper production in the United States from 1845 to 1907, inclusive.

Year.	Production.	Increase.		Average annual increase by decades.	
	Pounds.	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
1845	224,000				
1846	336,000	112,000	50.0	242,400	50.0
1847	672,000	336,000	100.0		
1848	1,122,000	450,000	67.0		
1849	1,568,000	426,000	40.0		
1850	1,456,000	[b]112,000	[b]7.1		
1851	2,016,000	560,000	23.1	1,467,200	27.0
1852	2,464,000	448,000	22.2		
1853	4,480,000	2,016,000	81.8		
1854	4,990,000	510,000	12.5		
1855	6,720,000	1,730,000	33.3		
1856	8,960,000	2,240,000	33.3		
1857	10,752,000	1,792,000	20.0		
1858	12,320,000	1,568,000	14.6		
1859	14,112,000	1,792,000	14.5		
1860	16,128,000	2,016,000	14.3		

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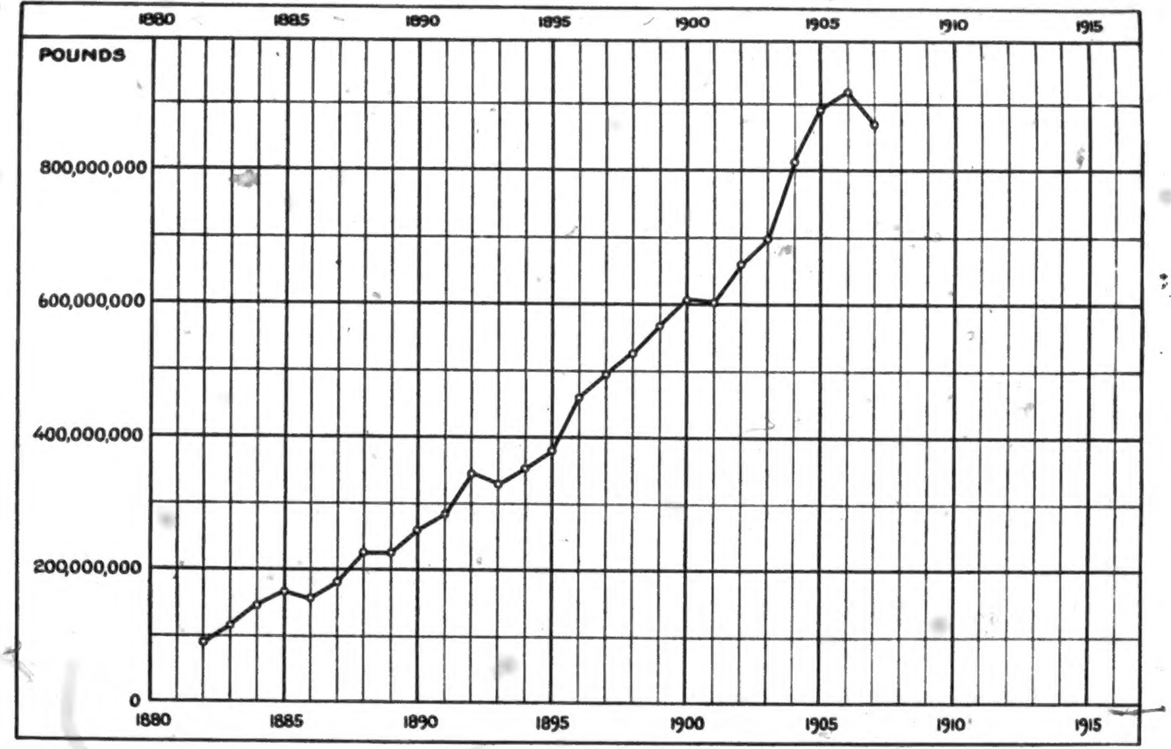
[a] Prepared with the assistance of Mr. L. C. Graton, of the U. S. Geological Survey.

[b] Decrease.



THE PRODUCTION OF COPPER IN THE UNITED STATES FROM 1882 TO 1907 (IN POUNDS).

Magnitude and growth of copper production in the United States, etc.—Cont'd.

Year.	Production.	Increase.		Average annual increase by decades.	
	Pounds.	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
1861	16,800,000	672,000	4.1	1,209,000	6.1
1862	21,160,000	4,360,000	20.0		
1863	19,040,000	[a] 2,120,000	[a] 5.5		
1864	17,920,000	[a] 1,120,000	[a] 5.9		
1865	19,040,000	1,120,000	6.3		
1866	19,936,000	896,000	4.7		
1867	22,400,000	2,464,000	12.3		
1868	25,984,000	3,584,000	16.0		
1869	28,000,000	2,016,000	7.7		
1870	28,224,000	224,000	1.0		
1871	29,120,000	896,000	3.2	3,225,000	7.2
1872	28,000,000	[a] 1,120,000	[a] 3.8		
1873	34,720,000	6,720,000	24.0		
1874	39,200,000	4,480,000	12.9		
1875	40,320,000	1,120,000	2.9		
1876	42,560,000	2,240,000	5.6		
1877	47,040,000	4,480,000	10.5		
1878	48,160,000	1,120,000	2.4		
1879	51,520,000	3,360,000	7.0		
1880	60,480,000	8,960,000	17.4		
1881	71,680,000	11,200,000	18.6	18,930,349	14.8
1882	90,646,232	8,966,232	12.5		
1883	115,526,053	24,886,221	27.4		
1884	144,946,653	29,420,600	25.5		
1885	165,875,766	20,929,113	14.4		
1886	156,735,381	[a] 9,140,385	[a] 5.5		
1887	180,920,524	24,185,143	15.4		
1888	226,361,466	45,440,942	25.1		
1889	226,775,962	414,496	.2		
1890	259,763,092	32,987,130	14.5		
1891	284,121,764	24,358,672	9.4	34,635,407	9.1
1892	344,998,679	60,876,915	21.5		
1893	329,354,398	[a] 15,644,281	[a] 4.8		
1894	354,188,374	24,833,976	7.5		
1895	380,613,404	26,425,030	7.4		
1896	460,061,430	79,448,026	20.9		
1897	494,078,274	34,016,844	7.4		
1898	526,512,987	32,434,713	6.6		
1899	568,666,921	42,153,934	8.0		
1900	606,117,166	37,450,245	6.6		
1901	602,072,519	[a] 4,044,647	[a] 0.7	37,554,189	5.5
1902	659,508,644	57,436,125	9.5		
1903	698,044,517	38,535,873	5.8		
1904	812,537,267	114,492,750	16.4		
1905	888,784,267	76,247,000	9.4		
1906	917,805,682	29,021,415	3.3		
1907	868,996,491	[a] 48,809,191	[a] 5.3		
Total production, 1845-1907	12,163,637,913				
Average annual increase, 1846-1907		13,880,213	15.0		
Average annual increase, 1846-1881		2,034,333	17.2		
Average annual increase, 1882-1907		30,282,201	9.9		

[a] Decrease.

PRODUCTION OF THE WORLD.

The world's production of copper has also increased rapidly, but not at the rate attained by the United States. From 274,000 metric tons in 1890 it has grown to 711,000 tons in 1907. To this amount the United States contributed, respectively, 118,000 and 386,000 metric tons. The paramount importance of this country is easily perceived.

The world's production, outside of that of the United States, increased as follows:

	Metric tons.
1890	156,000
1895	165,000
1897	182,000
1900	219,000
1905	297,000
1907	325,000

From this it will be seen that the increase was slow from 1890 to 1895, and that it then began to mount rapidly, doubling in the twelve years from 1895 to 1907.

No single country compares in importance with the United States. The supply from the Rio Tinto mines in Spain and Portugal is almost constant at 50,000 metric tons per annum; that of Germany and Chile likewise, with, respectively, 20,000 and 27,000 tons. Australia, Canada, Mexico, Japan, and Russia have shown rapid growth in the copper industry; among these Japan leads with an output of 49,000 metric tons in 1907. For the next few years increased production may confidently be expected from Canada, Mexico, and Russia. Copper deposits of enormous extent are reported to have been discovered in central Africa. Their product is not likely, however, to compete with other sources for five or seven years.

RESOURCES OF THE UNITED STATES.

For many years the bulk of the copper production has been divided between Michigan, Montana, and Arizona. In each of these States the increase has been rapid and continuous since 1880, but for a series of years, beginning with 1891, Montana far exceeded the other two States. In 1895, for instance, Montana produced 50 per cent; Michigan, 34 per cent; and Arizona, 12.6 per cent of the total output. During the last few years there has been a tendency to equalization, caused by the rapid advance of Arizona. In 1907, of a total of 869,000,000 pounds, Arizona yielded 257,000,000; Montana, 224,000,000; and Michigan, 219,000,000 pounds. Utah comes next with a production of 66,000,000 pounds. California yielded 34,000,000 pounds; Tennessee, 20,000,000 pounds; Colorado, 14,000,000 pounds; New Mexico and Idaho each, 10,000,000 pounds; Alaska, 7,000,000 pounds; Wyoming, 3,000,000 pounds; and Nevada, 2,000,000 pounds. These 12 States are the only ones which will have to be considered in more detail. The less important will first be disposed of.

COLORADO.

Colorado can be dismissed in a few words because the copper is largely recovered as a by-product from many mines with mixed ores, chiefly, in fact, from the Leadville mines. The State has no important copper mines and it is not likely that its production will exceed the figure of 1907, when special incentive to the recovery of this metal was given by abnormally high metal prices.

IDAHO.

Idaho has three copper districts of some importance—the Cœur d'Alene, the White Knob, and the Seven Devils. With copper prices at 13 cents the last two districts will probably not be able to attain a large yield. At present the greatest part of the production comes from the Snowstorm mine in the Cœur d'Alene district. With copper at 15 cents, or higher, the reserves of the State will be materially augmented and the present production could probably be increased.

WYOMING.

The State of Wyoming produces copper from the Encampment district, near the Colorado line. The deposits are fairly large and there is probably a considerable amount of low-grade ore in the district. Low-grade copper deposits are known to exist in Albany, Fremont, and Natrona counties. The State will never rank among the greatest producers in the country, but may be able to maintain a production of a few million pounds per annum.

NEW MEXICO.

New Mexico possesses large bodies of low-grade copper ores in the Burro Mountains and at Santa Rita. Exact figures can not be given, but with copper prices at 15 cents the Territory will probably be able to maintain its present output (10,000,000 pounds in 1907) for a long period of years. Many of the other mining districts, especially the Mogollon and the Organ, will continue to contribute to the total output. The copper-bearing sandstones of upper Carboniferous to Lower Cretaceous age are developed in New Mexico upon an enormous scale. They are present in the Zuni, the Nacimiento, the Mora, the Oscura, and many other ranges. Past experience has shown that with copper at 13, 15, or even 20 cents, these extensive deposits can not be profitably worked, except on a small scale for selected rich ores; but with prices above 20 cents they should come into the range of probable resources.

ALASKA.

The Territory of Alaska contains at least three copper districts of importance, the Kasaan Peninsula, Prince William Sound, and the Copper River region. From the first and second districts an output of 7,000,000 pounds was obtained in 1907. The deposits are irregular. The ores of the first district are of low grade but easily smelted. At copper prices of 13 cents the outlook is doubtful, but at a higher rate the peninsula may yield a considerable amount for a number of years. The deposits on Prince William Sound are considered promising, but are too little developed to allow a judgment as to future possibilities. Probably they will furnish a fair amount of copper. The Copper River deposits are likewise as yet in the prospect stage, but may in time develop into an important copper-mining district. The most promising property is at present the Bonanza mine, a large body of high-grade chalcocite ore. No data are as yet available as to its continuation in depth.

TENNESSEE.

At Ducktown, Tenn., the Tennessee Copper Company and the Ducktown Sulphur, Copper, and Iron Company are producing an aggregate amount of 18,000,000 to 20,000,000 pounds of copper per annum. The reserves of ore are believed to be sufficient for at least ten years. It is said that the former company has now developed and produced ore to the extent of 3,300,000 tons. About 389,000 tons of ore were mined by this company in 1907.

We now come to a consideration of the States which at present are of paramount importance in the production of copper. They are Michigan, Arizona, Montana, Utah, Nevada, and California.

MICHIGAN.

Michigan, which up to the present time has been the largest contributor of all the States to the total copper output of this country, began production in 1845 and has been steadily and increasingly productive ever since. The output in 1907 was over 219,000,000 pounds. The entire production has been drawn from the Lake Superior copper district of the northern peninsula, and the productive area is a belt 1 or 2 miles wide by about 70 miles long. Developments are more extensive than in any other copper district. The grade of the ores has steadily declined and now averages only about 1.1 per cent recovered. Costs of operations are extremely low, however, and the greater part of the present output can be maintained under the current copper market. The tonnage of ore that is reasonably assured is enormous and probably exceeds that in any other district; it is now being depleted at the rate of almost 10,000,000 tons annually. One company alone estimates 20,000,000 to 25,000,000 tons remaining in one lode (the "Calumet" conglomerate) in its ground that has been worked since the sixties of last century. Another lode (the Kearsarge) is being mined for 12 miles along its strike almost without break, and to depths on the incline ranging down to about 5,000 feet. A third very important lode (the Baltic) is being found much more extensive than formerly known, and, like the Kearsarge, promises to yield an enormous output before exhaustion. Two other lodes (the Osceola and Pewabic) are of much importance and may be safely counted on for large production for many years. Several of the smaller producing lodes will long continue to contribute to the State's supply, and some of the extensive development in the northern end of the district is likely to bring out important resources.

The conglomerate ores, which so far have yielded more than half the total output and are decidedly richer than the amygdaloid ores, will probably cease to be productive, at the present rate of working and under normal prices, at the end of fifteen years—twenty at most. But the amygdaloid ores, which are much more cheaply worked and in this way offset their lower yield, are able to maintain the district as one of the great copper regions of the world for many years to come. The deepest workings have now attained a vertical depth of practically one mile, and as the workings are extended farther down, the increasing cost of operation and the decreasing grade of ore will ultimately make mining unprofitable. While this condition seems not far in the future at certain local points, its effect on the general output of the district will, to judge from present tendencies, be felt at a very remote time.

Copper is known to occur for many miles beyond the southwestern end of the productive belt, but the development of important resources there is as yet problematical. It is probable that at best that section can achieve important output only under higher prices than can be reasonably expected for many years.

ARIZONA.

The foundation of the present production of Arizona, which in 1907 was about 257,000,000 pounds, was laid in 1873, when mining began in the Morenci district. Within a few years the Bisbee district became a producer and the ores of the old silver district at Globe became chiefly valuable for copper. Shortly afterward the United Verde mine at Jerome became an important producer. The production of these four districts increased steadily and rapidly, and in 1907 they produced jointly over 240,000,000 pounds, or more than the total yield of any other State. While there are a large number of other producing districts in the Territory, of which two or three are of decided promise, these four principal centers of production must be chiefly relied on for many years if Arizona is to maintain her output.

BISBEE.

The Bisbee district produced about 110,000,000 pounds in 1906, and practically all of it came from ores of relatively high grade. Most of the output was from secondary or enriched ores, and was produced at a cost low enough to maintain the district as an important producer with prices decidedly lower than at present. The principal companies are known to have good reserves blocked out, but figures as to tonnage and tenor are not available. There is a fair outlook for adding laterally to the productive area. The lowest workings are about 1,400 feet deep, and the primary or little-enriched sulphide ore of good grade encountered at that depth is an encouraging indication of possibilities.

MORENCI.

The high-grade ores of the Morenci district have been largely exhausted, and for a number of years the chief source of production has been the comparatively low-grade concentrating ores formed by secondary enrichment. The production in 1907 was about 63,000,000 pounds. A large tonnage is still doubtless available for extraction, but at a depth which only in a few places exceeds 400 feet the workable ores give way to the original pyritic deposits that are of too low grade to be profitably worked under any conditions that can at present be reasonably forecast. The ground that is possibly copper bearing has not yet been entirely prospected, and during the past three years of good prices the principal operators have conserved the better-grade ores. But it seems probable that the district has about reached its climax in annual output, and that a sustained period of low prices would cause the production to decline sharply.

At Bisbee and at Morenci the precious metals occurring with the copper are not sufficiently plentiful to have appreciable effect on conditions of production.

GLOBE.

The Globe ores likewise were formerly of high grade, but the district, which produced 35,000,000 pounds in 1907, is relying more and more on its medium and low grade ores. The bulk of the present output is from enriched ore. Lean pyritic ore has been reached at a depth of about 800 feet, but the secondary ore of workable grade has been developed in places to the present maximum depth of about 1,200 feet. There is reason to believe that some of the underlying sulphide ore may be profitably extracted, but as a source of important contribution to the copper supply this is very uncertain. Recently the Miami Copper Company has developed a very important low-grade deposit of the well-known type, consisting of disseminated secondary sulphides. The company estimates 4,200,000 tons of 2.9 per cent ore developed and 2,200,000 tons of probable ore in addition, with good prospect of increasing this tonnage. They estimate that in all probability a total of at least 250,000,000 pounds of copper can be taken from the mine as at present developed at a cost of 9 cents per pound. Production from this property is expected to begin in the near future. In the vicinity of Globe there is without doubt a large tonnage of ore, partly of good grade, not as yet altogether systematically developed. Promised improvement in local transportation and bettered metallurgical conditions resulting from increase of sulphide ores produced in the district will almost certainly be followed by increased production from this outlying territory, but the magnitude and persistence of this supply can not now be foretold.

JEROME.

The Jerome district, in Yavapai County, produced 33,000,000 pounds of copper in 1907. As in former years, nearly all this came from the United Verde mine. The ore body is a great lens of pyrite and chalcopyrite in schists and has been opened by workings to the 1,000-foot level, beyond which depth the ore is reported to continue. There is undoubtedly a large tonnage yet to be extracted above this level. Gold and silver are present to the extent of about 1.4 cents per pound of copper, and the copper percentage is high, the ore ranking with the Bisbee ores as the richest now mined on a large scale in the United States. Prospecting in the surrounding region has not as yet disclosed any other deposits of importance.

OTHER DISTRICTS.

At the Silver Bell district, in Pima County, important developments have been made and improvements are nearly completed to largely increase the production of 1907, which was over 5,000,000 pounds. Contact-metamorphic sulphide ores of both smelting and concentrating grade have been opened and the tonnage exposed is reported to be large. In the Mineral Creek district of Pinal County the Ray Consolidated Copper Company has opened a disseminated chalcocite body in porphyry, and estimates indicate that about 3,000,000 tons of about 2.4 per cent tenor have been already developed and can be profitably worked with copper selling at 12 cents. A large tonnage of low-grade garnet-chalcopyrite ore is reported as existing in the Saddle Mountain region, in Gila County, but it is not certain that it can be worked at the present metal market. A large quantity of low-grade ore consisting of copper minerals disseminated in sedimentary rocks is known in the Grand Canyon region, but development has been slight and no generally satisfactory method of reduction has yet been found for application at recent prices of copper.

These four regions have not yet been studied by members of the Geological Survey, and further definite information is not available.

A few million pounds of copper are produced annually in Arizona incidental to the recovery of precious metals. This will doubtless continue, and the probability is that the quantity will increase somewhat. While this source of supply will be relatively independent of the price of copper, it probably can never be of much importance.

The prospect of discovering new important copper fields in Arizona is perhaps brighter than in any other State or Territory.

MONTANA.

The importance of Montana as a copper-producing State began in 1880 with the advent of railroad transportation to Butte, the only large copper district of the State. Production increased with great rapidity, and in 1887 the district was the most productive in the world. It has held that rank almost steadily to the present time, as Montana led in the production of copper until 1907, when it was surpassed in this respect by Arizona. The production of the State in that year was about 224,000,000 pounds, nearly all of which was derived from Butte. The ore bodies of Butte are secondarily enriched portions of pyritic replacements and impregnations of zones of crushed granitic rock. In the early years the ores were of extremely high copper content and carried much silver. Now the greater part of the production is from rather low-grade concentrating ores, and the recovery from all ores is but little over 3 per cent copper. The yield of precious metals is more than 2 cents per pound of copper. The principal output is from a very small territory, and prospecting in the outlying ground during the last few years has failed, in most cases, to give encouraging results. A large tonnage of ore is undoubtedly still available for extraction, but lean pyritic material has been encountered in a number of places at about the same depth (the 1,600-foot level of certain mines) and most of the good ore bodies that occur at greater depths, down to 2,600 feet, are probably to be regarded as localizations of enrichment along certain easily permeable channels. The cost of producing copper is high and the output at the rate of 1905 and 1906, or even of 1907, probably can not be maintained for a long period on copper at 13 cents per pound.

UTAH.

The production of Utah has increased greatly during the last few years. In 1903 the output was approximately 30,000,000 pounds, while in 1906 it had attained 66,000,000 pounds, with prospect of still further increase. The Utah copper is mainly derived from the Bingham district, though smaller quantities are obtained from the Tintic and Frisco districts. All these ores yield also much gold and silver, and their extraction is therefore to a certain extent independent of the price of copper. A production of about 50,000,000 pounds could undoubtedly have been maintained for a series of years, as new reserves were constantly discovered. The recent discovery and utilization of the low-grade Bingham porphyry ores, probably the largest single body of copper ore known in the United States, will, however, advance Utah still further in the rank of the copper-producing States. The two largest companies which treat this ore estimate the aggregate reserves of ore blocked out or partially developed at 120,000,000 tons, which, provided that all of this ore can be extracted, should yield a very large quantity of copper, besides a considerable amount of gold and silver. The yield thus far is somewhat below 2 per cent copper. The copper can be produced cheaply, it is claimed at 8 cents per pound. The tonnage to be treated per day in the plants of the Utah Copper Company and the Boston Consolidated Copper Company is over 9,000 tons, or 3,150,000 tons per annum. At this rate the ores would last about thirty-eight years. In addition a large amount of ore of somewhat lower but probably workable grade is partly developed.

NEVADA.

Until recently Nevada was of little importance as a copper-producing State, but the development of the Ely and Mason Valley districts have materially changed the outlook. At Ely low-grade but enormously large copper deposits have been opened and will begin production in 1908. The three companies working at Ely, the Nevada Consolidated Copper Company, the Cumberland-Ely Mining Company, and the Giroux Consolidated Mines Company, report an aggregate of about 28,000,000 tons of developed and probable ore containing about 2 per cent copper with some gold and silver. The mills erected will have a total capacity of 4,500 tons per day, or 1,500,000 tons per annum. The proved reserves would therefore last about nineteen years. The total cost of mining and reduction will, it is believed, be low; it is claimed less than 10 cents per pound of copper. It is thought that the output of the Nevada Consolidated will be at the rate of 24,000,000 pounds per annum. In the Mason Valley district near Yerington important bodies of ore have also been opened and will probably soon contribute to the output of Nevada.

CALIFORNIA.

The copper production in California began in Calaveras County about forty years ago, but the industry there soon declined and it was not until 1897, when the Shasta County mines began copper production, that the output of this State became important. The production in 1907 was over 33,000,000 pounds.

SHASTA COUNTY.

The Shasta County copper region, which in 1907 produced about 28,000,000 pounds, embraces four districts within an area about 6 by 20 miles. Rich copper-silver ores were first worked at some of the mines, but these have been exhausted, and practically the whole output is at present derived by smelting massive pyritic ores, which yield on the average about 3.6 per cent copper and nearly 3 cents in gold and silver per pound of copper. The ore bodies are large replacement bodies, mostly in porphyry, and in most cases are flat-lying lenses; in a few cases the ore bodies are more nearly vertical. A very large tonnage is now blocked out and in process of extraction. One company has several million tons practically developed, and four other companies have proved up large reserves. One of the largest bodies has been practically worked out and the limits of most of the others are now known. Additional deposits may be discovered from time to time, for the region has not been thoroughly prospected, but the probability is that the best deposits existing are already known. Some of the mines probably have ore of too low grade to be continuously worked with profit under the current prices for copper, and others are dependent for present operation on the simultaneous production of sulphuric acid from the ores. Under favorable metal prices the production of the region is likely to increase rapidly and then after a number of years to decline sharply.

OTHER DISTRICTS.

The only other copper-producing district of any importance in California is in Calaveras County, where sulphide ore of good grade is found in schist. The production has varied greatly from year to year. In 1907 it was somewhat over 4,000,000 pounds. Details as to the probable future of this region are not available, but the outlook is generally considered good.

There is a long stretch of country in the western foothills of the Sierra Nevada where copper is known to occur mostly as lenticular sulphide bodies in schist or slate. Small production has been made from time to time. At most points developments are meager and the future is unknown, but there is reason to believe that with proper application of capital, improved transportation, and good copper prices, this district might make a considerable output. At the Dairy Farm mine, in Placer County, on this belt, a large body of sulphide ore has been blocked out and extraction will probably begin in the near future. The ore is not of high grade and its extension much beyond the ground thus far developed is not certain.

Small production comes from Inyo and San Bernardino counties, in the southern part of the State, but developments as yet do not warrant relying on that region for an important copper supply.

CONCLUSIONS.

The visible reserves of copper ore in the United States are much larger than those of lead ore. Moreover, they are very much larger now, at the maximum of production, than they have ever been before. And yet, upon perusing the preceding notes it is evident that few companies have reserves for as much as ten years and that only in one case are they believed to be sufficient for forty-five years. On its face this condition seems discouraging, at least when we compare it with the enormous reserves established in the investigation of the coal-mining industry. As has been explained in the general part of this discussion, copper deposits differ so completely in their occurrence from coal beds that known reserves like those of coal can not be expected. Each year will, however, surely find extensions of reserves added to those already discovered and large new deposits of low-grade copper ores will also undoubtedly be opened. These possibilities are well illustrated by the discovery within the last two years of a 7,000,000-ton ore body near the old camp of Globe, Ariz., which one might reasonably suppose to be well prospected.

All these data of available reserves are based on copper at about 13 cents per pound. A large part of them would prove unprofitable to extract should the value of the metal sink much below that figure. Should copper increase to 15 or 20 cents per pound the reserves of many mines would unquestionably be vastly increased. Should it go above 20 cents per pound, still more extensive reserves would be available in the cupriferous sandstones of the Southwest. These conclusions, again, are based on present methods of working and recovery. Should further great improvements be made in these processes the limits indicated by the prices might be materially altered.

The copper resources of the United States are believed to be large enough to respond for a number of years to a demand increasing at the rate of 30,000,000 pounds per annum. It is to be anticipated that should this demand continue for a long period the scarcity of ore would ultimately be felt and result in a rising price for the metal. This again would undoubtedly cause the substitution of other metals, like aluminum, for copper whenever possible.

All these considerations have left the foreign supply out of the question. If recent reports are correct, central Africa contains enough copper to supply the world for years to come.

The whole problem of the ores supply contains so many unknown quantities that a final and definite answer is impossible. In the last analysis, however, it comes down to the question whether it is better for a country to reserve its copper for the future, when its value is an unknown quantity, or extract the ore at as rapid a rate as possible when profit is assured. It is believed that the latter method is the best, if at the same time avoidable waste is prevented.

CONSUMPTION.

Only a part of the copper produced is consumed in the United States; exports have been maintained on an increasing scale for the last thirty years. At the present time some, but not much, copper ore is imported to our smelters. On the other hand, there is a large output of foreign raw copper which is refined in the United States. In 1907 the total foreign copper refined in this country amounted to 248,000,000 pounds, or one-third of the domestic production of refined new copper, which for the same year was 784,000,000 pounds.

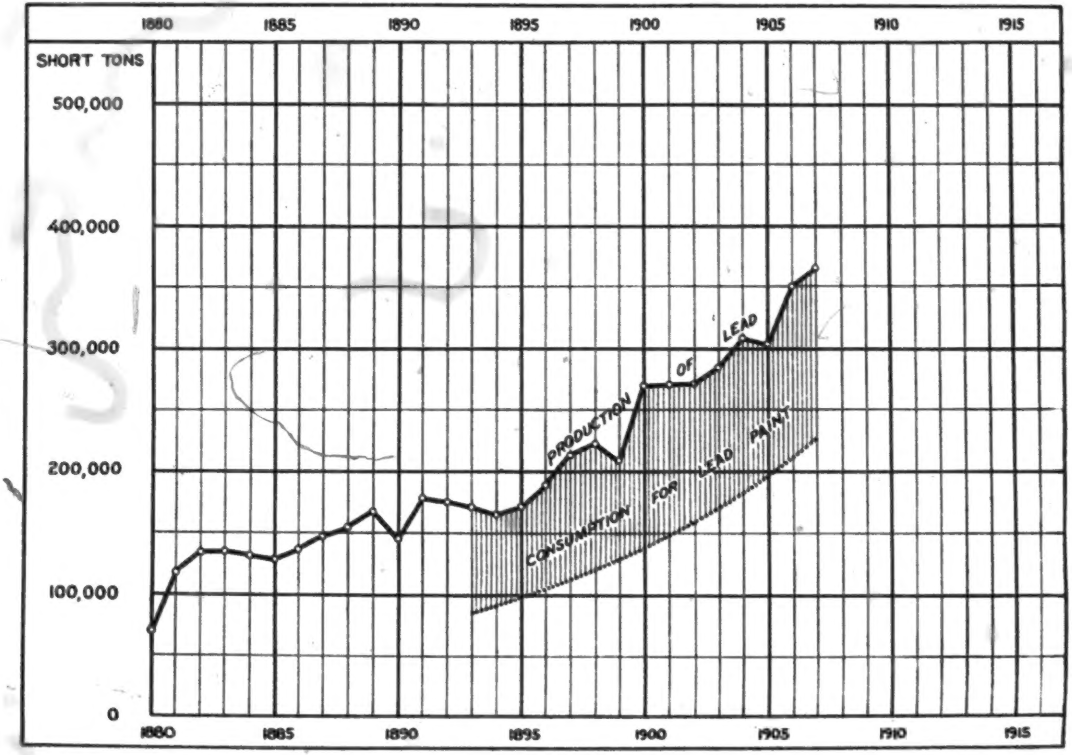
There is no duty on copper or copper ores to interfere with the natural operations of supply and demand. The copper industry has developed in a natural and free manner and no single concern has yet obtained control of the market.

The domestic consumption has increased from about 350,000,000 pounds in 1900 to 685,000,000 pounds in 1906. In 1907 it had decreased to 485,000,000 pounds. To this should be added the consumption of copper recovered from scrap, which was about 60,000,000 pounds in 1907, making a total consumption of about 545,000,000 pounds.

The uses are principally for wire or other electrical purposes, brass, castings, and sheet copper. There is no such great amount permanently lost as in lead and zinc, and a large quantity of scrap will be available with increased production and consumption.

WASTE.

It is not believed that the waste in the mining of copper ore is excessive. Ores too poor to extract at prevailing prices are, of course, left in the mine. But with present methods of extraction, whether timbering, filling, caving, or steam-shovel methods, there is little profitable ore left in the mines.



THE PRODUCTION OF LEAD IN THE UNITED STATES FROM 1880 TO 1907 (IN SHORT TONS).

Much larger are the losses in concentration. The principal valuable mineral in the concentrating ores is chalcocite, which is easily slimed; the loss may be 30 per cent of the metal contained, and it is not always easy to avoid it. Storage of tailings should be enforced, even though in many cases the grade of the ore is so low that there is little present probability of utilization. The waste in copper smelting is not large and the slags are easily available for resmelting; at many reduction works old slags are used as a fluxing material.

LEAD.[a]

PRODUCTION OF THE UNITED STATES.

The diagram shows by graphic method the annual production of lead in the United States for the last twenty-eight years. From 129,000 short tons, in 1885, the production increased at a moderate rate to 1895, when it was 170,000 tons, an average increase of about 3,700 tons per annum for eleven years. The second epoch, from 1895 to 1907, presents radically different conditions. The output rose rapidly and steadily, except for small setbacks in 1899 and 1905, at an average increase of almost 15,000 tons per annum, or about four times as rapidly as in the previous eleven years. In 1895 the total was 170,000 tons; in 1907, 365,000 tons. The increase since 1895 has been at an almost even rate, by average, as clearly indicated on the diagram. Should this rate of increase be maintained, the production of 1910 would be 410,000 tons, and that of 1920, 560,000 to 580,000 tons.

PRODUCTION OF THE WORLD.

In 1907 the world's production of lead was about 965,000 metric tons, while that of the United States amounted to 317,500 metric tons, or about one-third of the whole.

The world's production of lead has not advanced at so rapid a rate as that of the United States. From a total of about 721,000 metric tons in 1897 the production has increased to about 965,000 tons in 1907. If we consider all countries except the United States, the figures for the same period of eleven years would be 541,000 tons and 648,000 tons, an average annual increase of 9,700 metric tons. Upon closer examination it is found that the total production of all countries except the United States increased rapidly—in fact, at the remarkable rate of 23,000 tons per annum from 1897 to 1903. On the other hand, a steady decrease has taken place since that time, from 702,000 metric tons in 1903 to 647,000 metric tons in 1907, equivalent to a rate of 11,000 tons per annum. And this has happened in the face of advancing lead prices.

Considering the foreign supply in more detail, the greatest output comes from Spain (186,000 tons in 1907). The quantity has remained approximately constant from 1897 up to the present time. Spain's resources of lead are known to be great, but it may be seriously doubted whether the present production can be materially increased. Germany contributed about 143,000 tons. Up to three or four years ago a steady increase had been shown in Germany, but in the last few years, in spite of rising quotations, the production has receded. Australia yielded 97,000 metric tons, mainly from Broken Hill, but its output has been decreasing rapidly during the last few years from the maximum of 141,000 metric tons reached in 1903. Practically the same may be said of Mexico. From Mexican ores about 72,000 metric tons of lead were obtained in 1907. The rich ore deposits of Sierra Mojada and other places are being exhausted.

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[a] Prepared with the assistance of Mr. C. E. Siebenthal, of the U. S. Geological Survey.

The facts given above are significant. They show that the lead deposits of the world are being heavily drawn upon and that, barring new discoveries of great importance, which are somewhat unlikely, a further reduction in the world's output is likely. This reduction will probably be accompanied by a rise in the price of the metal. An advance of a few cents per pound will no doubt create new and large ore reserves in many countries.

RESOURCES OF THE UNITED STATES.

Of the 365,000 tons of lead produced in the United States in 1907, Idaho and Missouri yielded 236,000 tons, or nearly two-thirds. The output of 1907 was divided approximately as follows:

	Short tons
Southwestern Missouri	24,600
Southeastern Missouri	98,400
Idaho	113,000
Utah	62,000
Colorado	51,000
Other States	16,000
Total	365,000

In the following pages the production and possibilities of each State are taken up in sequence.

MISSOURI.

In southwestern Missouri lead is now mainly obtained as a by-product from crude zinc ores which average about one-half of 1 per cent in lead. The heavy lead ores occurred near the surface and are now almost exhausted. The present production of lead is mostly derived from the extensive flat ore bodies in the lower Carboniferous, known as the sheet ground. The portion of the sheet ground which has been mined up to date, say, in the last ten or twelve years, while comprising probably the richest part, constitutes not over the one-hundredth part of the probable sheet-ground territory. Much of this territory is, however, not workable at present ore prices. Large and economical plants will be one of the necessities of the future. Decreased cost of production and higher ore prices may lead to the opening of still deeper disseminated deposits which the drill has shown to exist at Joplin, Webb City, and Granby, and which have also been opened 10 miles south of Joplin. It is believed that the deposits of southwestern Missouri will be sufficient to keep up the present production for fifty years at least.

Although the district of Joplin has been examined in detail by the Geological Survey, it is impossible to measure the extent and richness of the probable ore with any degree of certainty. Any estimate in figures is little better than a guess. As lead is here a by-product of zinc-ore mining, what is said of the zinc-ore supplies holds good also for lead ore.

The production of southwestern Missouri remained fairly constant at 27,000 to 35,000 tons of lead concentrates per annum from 1894 to 1905. In 1906 and 1907 a rapid advance took place, and in 1907 about 42,000 tons of concentrates were obtained.

In southeastern Missouri a pure lead ore is mined, containing an average of about 5 per cent of metallic lead. The important ore bodies occur disseminated at the base of a Paleozoic limestone at depths of 300 to 800 feet in fairly well defined runs or ore bodies, some of which are over 5,000 feet in length. The production has been maintained for many years. In 1892 about 42,000 tons of concentrates and shipping ore were obtained. In 1901 this had increased to 110,000 tons. During the last few years the output has increased rapidly, and in 1907, 157,000 tons of concentrates were produced. This rapid advance is chiefly due to the enlarged plants of the St. Joseph Lead Company and affiliated interests, capable of handling 3,900 tons of ore per day, and to the 2,400-ton concentrating mill recently erected by the Federal Lead Company, which is allied to the American Smelting and Refining Company. No data are available giving the results of the extensive prospecting operations by diamond drills undertaken by these companies, nor has the region been covered by the investigations of the United States Geological Survey. Statements obtained from well-informed engineers indicate that the ore-bearing area covers from 30 to 40 square miles. While this ore-bearing area is large, it is by no means inexhaustible. It is believed that the maximum of production will be reached in a few years. The supply will, however, undoubtedly last for a great number of years, and it is undoubtedly true that there is a great extent of unprospected territory with possibilities of ore deposits at a considerable depth, especially on the south and southwest sides of the St. Francis Mountains.

IDAHO.

In Idaho the Cœur d'Alene district is the principal source of production. Discovered about 1885, this district has rapidly and continuously increased its production until it now exceeds 100,000 tons of metallic lead per annum. The deposits are strong fissure veins in quartzite. The principal properties are controlled by the Bunker Hill and Sullivan Mining and Concentrating Company and the Federal Mining and Smelting Company, the latter affiliated with the American Smelting and Refining Company. The district has been studied by Mr. F. L. Ransome, of the Geological Survey,[a] who expresses his belief that the district gives promise of long-continued activity. Mr. Ransome also states that the ore shoots extend to great depth with remarkably little change in the character of the ore. The Bunker Hill and Sullivan mine, which has distributed over $9,000,000 in dividends, may reasonably be expected to continue its present rate of production for a score or more of years. Similar conclusions apply to several other mines. New discoveries will probably be made, as, indeed, in the last few years two important mines have been added to the producers. The total production of lead and silver will probably continue to increase for several years. The Bunker Hill and Sullivan, the greatest single producer, yielded in 1907 about 35,000 short tons of lead. On its lowest level the ore shoot is said to be as rich as in any of the upper workings, and there seems to be no reason why mining operations could not be extended for several thousand feet below this level. The underground workings have now, according to a recent circular to stockholders, undercut and partially developed 3,000,000 tons of ore, expected to contain 11 per cent of lead and 4.82 ounces of silver per ton, a total of about 330,000 tons of lead. A few of the deeper mines are now, according to Mr. Ransome, extracting ore much leaner than this and may cease to be profitable in a few years. There is also the probability that in general more zinc and less lead will be found as the mines attain greater depth. But on the whole the prospects decidedly encourage the belief that the Cœur d'Alene district will be able to maintain or somewhat increase its present production for some twenty-five years at least.

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[a] Prof. Paper No. 62, U. S. Geological Survey.

UTAH.

Utah has long been an important producer of lead, chiefly from three districts, the Park City, Bingham, and Tintic. The Frisco district has lost its one-time prestige in respect to this metal. The total output of Utah now (1907) stands at 64,000 tons, and for a number of years has remained fairly constant. The Park City district is the most productive, yielding about 23,000 tons per annum. The lead ore is contained in strong fissure veins and replacement bodies which promise a long-continued output. The bulk of the remainder, or about 40,000 tons, has until recently been derived from the Bingham and Tintic districts, but in late years the American Fork and Stockton districts have greatly increased their production. Utah is rich in lead ores, and its output bids fair to be continued on the present scale for many years to come. On the other hand, there is little probability of a greatly increased output. Nobody is in position to furnish even approximate figures as to the reserves, and few of the lead mines have, in fact, reserves for more than two or three years ahead.

COLORADO.

Since 1879 Colorado has always been one of the most important lead-producing States. The production reached a maximum when the great ore bodies of Leadville were discovered about twenty-five years ago. It has fluctuated considerably, ranging from 40,000 tons to 80,000 tons of metallic lead between the years 1881 and 1908. During the last few years it has slowly declined and in 1907 was estimated to be 51,000 tons. Leadville has always been the most prominent district and its production was greatest when the enormous bodies of carbonate ore were worked, from 1880 to 1890. During recent years the output of Leadville has remained fairly constant at about 23,000 tons, or one-half of the total production of Colorado. The rich oxidized ores are almost exhausted. The deeper ore bodies are of great size but are poor in lead. It is largely owing to the utilization of zinc ores that Leadville has been able to maintain its production; the tonnage of zinc-lead ores, poor in lead, is now about one-third of the tonnage of the lead ores and the siliceous ores. Undoubtedly a large output of lead can be maintained for many years, but it will probably slowly decrease. The rest of the Colorado lead is mainly derived from Aspen and Creede. The former district is slowly decreasing in importance. Regarding the latter, the information at hand is not extensive, but it is believed that the district is in position to maintain its output for a number of years.

From the preceding it appears that there is little chance of increase in the lead production of Colorado. More probably it will gradually decrease. The State is rather throughly prospected, and the chance of new discoveries is correspondingly small.

OTHER STATES.

None of the other States yield enough to become a seriously considered factor. The total output from them was 16,000 tons in 1907. Probably many districts will increase in importance; others will fall out. For a number of years to come we may count with some confidence on this amount as their aggregate total. The Eureka mines in Nevada, once prominent, are now being reopened, but thus far no ore bodies similar in importance to the old bonanzas have been reported. The railroads now being built in the State will open a considerable territory, which will yield a fairly large amount of lead from newly developed smaller districts or from rehabilitated old districts like Pioche. Discoveries of new lead-producing districts like Leadville or Park City or the Cœur d'Alene are of course always possible, but they do not seem very likely.

Summing up these data, it is believed that the lead production of the United States can be maintained at the present figures for a number of years—possibly twenty years—but that after some such time it would be more likely to decrease. Barring new discoveries of great value, a continued increase of production, like that which has taken place in the United States since 1895, is very improbable. With increasing demands for consumption the price of lead would gradually rise, and in such case of course each cent permanently added to the price of the metal would make available large additional ore reserves, but even at an increased price there is little probability of an indefinite increase on the scale of the last few years.

CONSUMPTION.

For the last ten years the United States has consumed all of the domestic lead produced, and in addition a variable but small amount has been imported. The consumption has practically kept step with the production.

A feature of much interest is that over one-third of the lead is used in the manufacture of white lead and consumed as paint. This feature is shown in the accompanying diagram. In 1907, 135,000 tons of metallic lead were so used. White lead is used more than any other substance for paint, although the manufacture of zinc white and zinc-lead white has taken great steps forward during the last few years. Of course the lead so used is absolutely lost, and it does seem as if for these purposes some other material might be substituted for so valuable a metal, especially when, as shown above, the ore reserves are relatively low. Probably no other nation uses lead paint to the same extent as the United States; partly because here wood construction prevails; partly because our greater prosperity allows the use of more expensive paint. With general substitution of brick, stone, or cement (of which our resources are inexhaustible) for wood (of which our supply is rapidly diminishing), the demand for lead white would greatly decrease. Anything that could be done to encourage this change would be desirable.

SCRAP LEAD.

With increasing production and price a greater quantity of scrap will each year be remelted for consumption. In 1907, according to incomplete returns made to the United States Geological Survey, 25,000 tons of lead were thus returned to consumption; the latter is thus in reality at least 25,000 tons greater than the figures of production would indicate.

WASTE.

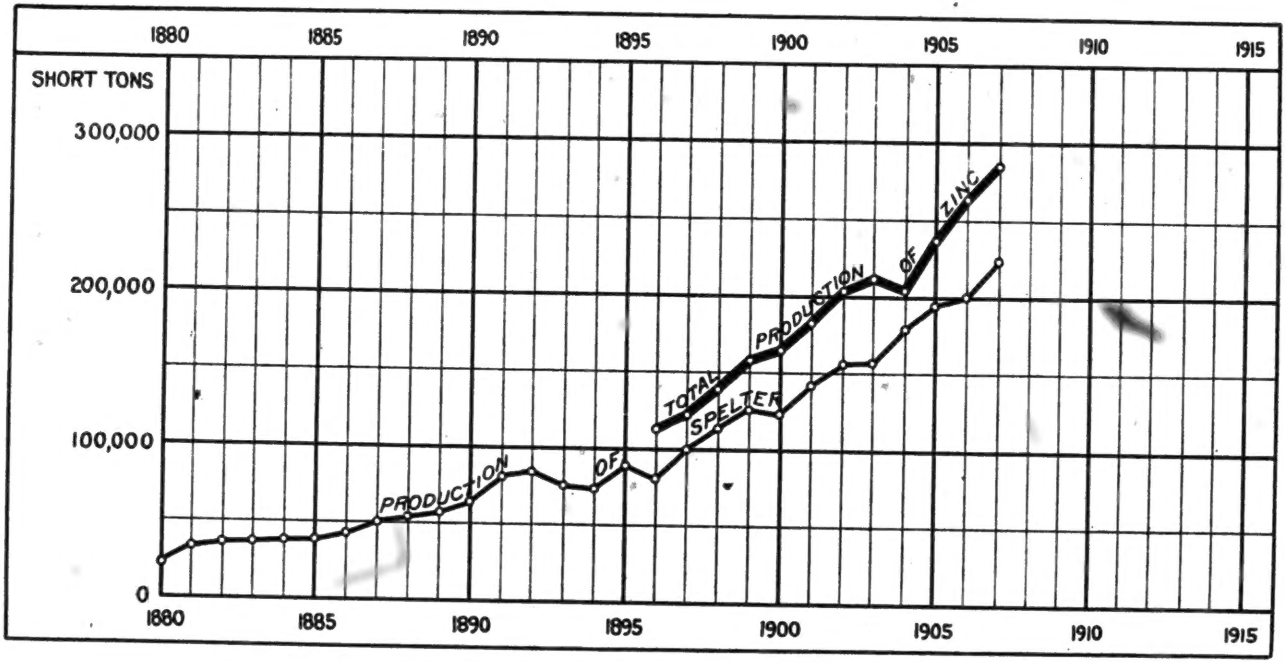
There is little waste in the mining of lead ores. Neither is there much waste in the smelting of the ores; besides, the slags are of course always available for retreatment, if necessary. The loss in smelting and refining is usually estimated as 5 per cent, although this figure is probably somewhat too high.

The greatest waste takes place in the concentration of lead ores. It is not nearly so great as in case of copper and zinc, but doubtless often amounts to 15 per cent. The best way to mitigate this feature would be to compel all owners of concentrating works to store their tailings.

The improvements in both concentration and smelting have been very great in the last fifteen years, and this fact has, of course, enabled the miners to handle lower grades of ore. A lead ore containing 4½ per cent of metallic lead is now worked in southeastern Missouri, and ore containing 5½ to 6½ per cent (with 2 to 3 ounces of silver) in the Coeur d'Alene district. Further reduction in the costs are probable, but not likely to be great as long as the present high scale of wages in the West continues.

TARIFF ON LEAD AND LEAD ORES.

The lead-mining industry has been to a high degree artificially stimulated by the duty on refined lead and lead ores. Under this protection our own resources have been strained to the utmost. We have put a premium on the output of lead and the result is shown in the price of the metal, which is higher in New York than in foreign markets. The control of the market in the United States has not unnaturally fallen into the hands of a trust. Both the smelting and the mining interests have been greatly favored, while the consumer has been paying the bills. Were the duty on lead and lead ore removed the western and central lead-mining districts would no doubt be forced to reduce wages and pay the strictest attenion to reduction of cost. The natural resources would, however, probably be less heavily drawn upon.



THE PRODUCTION OF ZINC IN THE UNITED STATES FROM 1880 TO 1907 (IN SHORT TONS).

Upper line shows total production of zinc as spelter and as zinc in zinc white, manufactured from ore. Lower line shows production of spelter.

ZINC.[a]

PRODUCTION OF THE UNITED STATES.

The zinc-smelting industry in the United States is of comparatively recent origin. From a small beginning of 23,000 tons of spelter in 1880, the production of spelter increased at a moderately rapid rate up to 1896, as shown by the diagram. This total increase in seventeen years was only about 60,000 tons, or at a rate of 3,500 tons per annum. From 1896 a much more rapid rate began. The average increase from 1896 to 1907 was at the rate of 14,000 tons per annum, or from 81,000 tons in 1896 to 223,000 tons in 1907. The rate of increase has been fairly uniform within this period, but was distinctly greater from 1903 to 1907 than from 1896 to 1903, the average annual increase during the former period amounting to 18,000 tons.

All these figures, it should be remembered, refer to spelter; a large part of the zinc ore is, however, used for pigments, chiefly zinc oxide, partly also zinc-lead white. The upper curve in the diagram shows the zinc in pigments added to the production of spelter. The amount of zinc used annually for paints has doubled since 1896 and is now about 60,000 tons. Taking this into consideration it is seen that the total production of zinc in the United States was 284,000 tons in 1907, and that the annual increase since 1904 has been 32,000 tons in 1905, 27,000 tons in 1906, and 21,000 tons in 1907. Assuming that a straight line from 1896 to 1907 represents the average tendency, the production in 1910 would be about 325,000 tons; in 1915, 395,000; and in 1920, 475,000 tons. Should the substitution of zinc oxide for white lead proceed on a still larger scale in the future than in the past, which seems possible, the figures at the years mentioned would be very materially increased.

PRODUCTION OF THE WORLD.

The world's production of zinc has increased since 1896 at a very rapid rate, but not quite at the pace set by the United States. The total production increased from 422,000 metric tons in 1896 to 737,000 metric tons in 1907. The production from all sources, excepting the United States, amounted to 352,000 metric tons in 1896 and 510,000 metric tons in 1907, an average annual increase of 14,300 tons.

The celebrated zinc mines in Belgium are still producing heavily, as are the mines of Silesia and at other points in Germany. New and very extensive supplies of ore are being received in Europe from Mexico and Australia, and deposits of great magnitude are reported to exist in Africa. The successful solution of the problem of ore concentration at Broken Hill, New South Wales, will enormously increase the shipments of Australian ores to European smelters, and it is considered possible that the mines of Germany and Belgium may have to reduce their output to avoid overproduction of zinc.

The United States now ranks first in production, having surpassed Germany in 1907.

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[a] Prepared with the assistance of Mr. C. E. Siebenthal, of the U. S. Geological Survey.

The production of zinc (spelter and zinc in oxide) in 1907 is divided approximately as follows among the States:

	Short tons.
Missouri	142,000
Wisconsin	20,600
Kansas	14,000
New Jersey	62,500
Colorado	30,400
Other States	14,500
Total	284,000

MISSOURI.

It will be seen that Missouri occupies the most commanding position, producing exactly one-half of the total domestic output. Practically all of this is derived from the southwestern or Joplin district. The ores now of most importance are contained in flat deposits in the so-called "sheet ground," which, at a depth of 150 to 250 feet, underlie a large area in this region. The known sheet ground is constantly increased; the extent of the actual known ore reserves is an unknown quantity; the extent of the area of possible ore is very large. It can be said with fair confidence that deposits of zinc ores underlie 50 square miles of territory, with strong probability that further exploration will add another 50 square miles. The portion of the sheet ground which has been worked during the last ten or twelve years, since such mining was first attempted, is between 1 and 2 square miles. Much of the remaining territory is certainly poor and contains considerably less than 3 per cent of zinc sulphide (including some lead), and whether it can be profitably worked is largely dependent upon royalty to the landowner as well as price of zinc. There is also some probability of opening lower deposits of zinc-bearing ground which have been shown to exist at Joplin, Webb City, and Granby and which now are being worked at Aurora at a depth of 325 feet. Superficial deposits will doubtless continue to be discovered and worked, though probably in lessening number and extent in the future. As the result of special study of the Joplin district by the United States Geological Survey, it is thought that the probable ore reserves will be sufficient to keep up the present production for fifty years at least.

KANSAS AND OKLAHOMA.

The zinc-bearing cherts and limestones extend from Joplin into the adjoining States of Kansas and Oklahoma. In Kansas the future can not be predicted, as the deposits so far developed have not been of sheet formation, but there are possibilities of finding extensive deposits in virgin territory and at greater depth in known localities. In Oklahoma the production is now small, but there are in the Quapaw district at least 12 square miles of ore-bearing blanket breccia. Very promising deposits have been opened at Miami, and the blanket breccia probably extends in this direction, making it reasonably certain that the mineralized area is as much as 20 square miles in extent, most of which will be available mining territory when ore yielding 2 per cent of concentrates can be profitably worked.

WISCONSIN.

According to Mr. H. Foster Bain, the extent of the zinc deposits in Wisconsin is fairly well known. The ore does not, as in Missouri, form extensive flat sheets, but shorter "pitches" and "flats." The zinc ore is usually found below the already mined lead deposits, and drilling operations during the last few years have given encouraging results. The production has increased rapidly and with higher zinc prices will probably increase still further. No estimate of actual or probable ore reserves can be given, but there is little doubt that the present production, with zinc at 5 or 6 cents per pound, can be continued for many years.

NEW JERSEY.

The large and in many respects remarkable deposit at Franklin Furnace is the only occurrence of importance in New Jersey. No recent estimate of the quantity of ore is available, but, according to a report by Nason,[a] the ore body in 1894 contained about 8,000,000 tons. According to the reports of the New Jersey Geological Survey, approximately 2,500,000 tons have been mined since 1904. The figures for the total ore reserves may be rather far off the mark, but they serve to show that the ore body is known to have definite limits and that its exhaustion is probably a matter of fifteen to twenty-five years at the present rate of ore production.

COLORADO.

About 1901 Colorado began to ship zinc ores to the smelters and shortly afterward a zinc smelter was built at Pueblo. The production rose rapidly, and, according to the mine reports of the United States Geological Survey, in 1906 attained 43,000 tons, calculated as probably recovered spelter and zinc in paint. In 1907, when the conditions, at least during the latter part of the year, were less favorable, the production was 30,400 tons. The larger part of this came from Leadville, in which camp the lower levels had disclosed large quantities of ore consisting of pyrite, zinc blende, and a little galena. Recent improvement in concentrating processes had made possible the recovery of this zinc and its separation from the pyrite. Large quantities of zinc also came from the Tenmile, Red Cliff, Aspen, Creede, Breckenridge, and Clear Creek districts. The margin of profit was in many cases small, no payment was as a rule obtained for the silver and lead contained in the ores, and the losses in concentration were great. When the lower prices of 1907 were established the majority of the mines ceased shipments.

No figures of ore reserves even approximately correct are available to the Geological Survey, nor can they be obtained, but there is no question whatever that the resources of Colorado in zinc ores are very large, and that with favorable prices an output much larger than that of 1906 could easily be yielded by the State for a long period of years. The ores occur under entirely differing conditions from those of the Central States. The deposits are fissure veins or irregular replacement ores in limestone, and are nearly always mixed,

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[a] Trans. Am. Inst. Min. Eng., 1894.

i. e., contain silver, copper, lead, and more rarely gold. Many mines once worked for lead have been impoverished by the prevalence of zinc in lower levels.

OTHER STATES.

Conditions similar to those in Colorado prevail in many of the Western States, notably in Utah and Idaho, both of which shipped a considerable amount of zinc ores in 1906 and 1907. From Park City and Frisco in Utah and from the Cœur d'Alene district in Idaho important shipments were made. New Mexico, though not figuring conspicuously in the production of 1907, has some very large zinc deposits at Magdalena and smaller deposits at many places. Its yield of zinc in 1906 was about 8,000 tons, and with favorable conditions this amount could probably be doubled and be continued for a considerable period of years.

Zinc ores in considerable quantities could be furnished by Arizona and Nevada. Prospecting for these ores has not been especially active in the West. In fact, deposits containing zinc have until within a few years rather been shunned on account of the difficulty of treating such ores in copper and lead furnaces and the difficulty of marketing them as zinc ores with profit. New discoveries may therefore be anticipated.

In conclusion, the supply of zinc at prices of 4 to 5 cents is not very large, and will come chiefly from Missouri and New Jersey. At prices above 5 cents the supply will probably be ample for such length of time as we can reasonably foresee. It is thought that our resources of zinc, especially in the West, have just begun to be developed.

CONSUMPTION.

Since 1876 the domestic production has been sufficient to supply the demand, and the importations have been small. A small amount of high-grade spelter and ore has been exported, mostly from New Jersey. There is, it is true, an import duty on spelter practically prohibiting foreign importations, but on the other hand, during the last three years 25,000 tons of spelter have been obtained per annum from Mexican ores, which is equivalent to about one-eighth or one-ninth of our domestic production. There has been a long controversy about the construction of the law in respect to zinc ores. The case is still in the courts and, pending final decision, duties are still collected, to be refunded later should zinc ores be adjudged duty free.

As already noted, about 60,000 tons of the metal are used per annum for the manufacture of white paint. This amounts to one-sixth of the whole output, and is of course permanently lost. Next in importance comes the metal used for galvanizing, and this consumed, in 1905, 100,000 tons; in 1906, 124,000 tons; and in 1907, 149,000 tons, an increase of 49 per cent in two years. In 1907 this amounted to more than half of the total production of zinc. The remainder of the spelter output is about equally distributed between brass and sheet zinc. All these products seem indispensable for the growth and development of the industries, and it is believed that the consumption of zinc will continue to increase at the recent rate for several years to come.

The zinc industry has been less protected than lead mining and smelting. There is no trust controlling the output or the principal part of the output, and it appears to be in a healthy condition. Free importations of zinc ore will act as a healthful check on the too rapid consumption of our resources, and it would probably be well to allow them in the future.

Much zinc can be recovered from the galvanized products, and this recovered metal, which in 1907 amounted to 13,000 tons or more, will of course increase as the output grows larger.

WASTE.

In no metal industry is the waste more startling than it is in the production of zinc. In mining, Missouri must be considered first. Owing to the occurrence of the ore in flat sheets, it is necessary to leave pillars to support the roof, filling or timbering being too expensive. About 14 per cent of the ore therefore remains in the mine, although, of course, care is usually taken to select the poorer ground for pillars as far as possible. In the West, owing to the expensive treatment and shipment of the ore, much low-grade ore is left in the mine, but this is not necessarily a complete loss unless the mine is entirely wrecked.

In concentrating, the losses are enormous. Somewhat better conditions now prevail, but in many cases at least not more than 60 per cent of the assay value is saved in the concentrating works. From 30 to 35 per cent is perhaps an average loss. Southwestern Missouri has been the chief offender in this respect. While the mining and milling costs there have been extremely low, this has been accomplished at a heavy loss of metal. The miner has not been entirely to blame, for the heavy royalties exacted by the landowners have forced him to adopt these wasteful methods. Lower royalties, better concentration works, and obligatory storage of tailings will help these conditions.

In the smelting of zinc ores the loss is heavier than in any other metal; the average is probably nearly 20 per cent of the assay value, and the loss is heavier in western complex ores, containing much iron, than in Missouri Valley ores. It is claimed that the smelter practice has been behind that of Europe. These conditions are being remedied, but still further metallurgical improvements are most urgently desirable and will be soon attained. The western ores usually contain silver and lead; sometimes also copper. Under present conditions these metals are often wasted, and only under exceptional conditions does the miner obtain payment for them. There is vast room for improvements in the zinc industry, and attention to the matter will materially increase the life of our zinc deposits.

The total loss from ore in the ground to spelter is rarely less than 40 per cent.

THE PHOSPHATE DEPOSITS OF THE UNITED STATES.

By F. B. VAN HORN,
United States Geological Survey.

INTRODUCTION.

The occurrence of rock phosphates in the United States has a very important bearing upon the agricultural industry, since many plants can not exist without the presence of phosphoric acid in the soil. Growing crops deplete the soil of its phosphoric acid, and if no steps are taken to restore this substance the soil must eventually become nonproducing.

Florida, South Carolina, and Tennessee have for several years been the main sources of phosphate in the United States. North Carolina, Alabama, and Pennsylvania have produced phosphate rock, but never on a large scale, and there is at present no production from these States. In 1900 Arkansas entered the field as a producer, and in 1906 a new field was discovered in Wyoming, Idaho, and Utah.

DEVELOPMENT OF THE INDUSTRY.

Phosphate mining began in the United States in 1867 in South Carolina. The existence of the rock had been known since 1837, but the possibilities of its commercial use were not recognized until 1859. According to Otto A. Moses:[a]

> In 1859 Professor Shepard and Col. L. M. Hatch suggested the utilization of phosphatic marls in the manufacture of commercial fertilizers and started a factory at or near Charleston, which was, however, soon abandoned. Remains of their compost heap were utilized by neighboring farmers with good effect long after the war.
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> At the close of the war Dr. N. A. Pratt, formerly connected with the niter bureau of the Confederacy, visited Charleston with the object of starting sulphuric acid chambers. About this time Dr. St. Julien Ravenel, of Charleston, who had mined marl extensively at Stoneys Landing, on Cooper River, for the manufacture of cements, noticed the nodules, analyzed some of them, and found them to contain much phosphate of lime. He became engaged soon after in the manufacture of commercial fertilizers from foreign phosphate rocks. Then followed the discovery (in August, 1867) which has been of such vital importance to agriculture and the prosperity of South Carolina. Pratt and Holmes (Charleston Mining Company), Ravenel and Dukes (Wando Company), then located territory. The value of the deposits became known; other available beds were discovered, and many persons and considerable capital were soon employed in developing the new industry by mining the crude rock and exporting or manufacturing it on the spot into superphosphates. Later on the beds of many navigable streams were found to be largely paved with the valuable substance.

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[a] Mineral Resources U. S. for 1882, U. S. Geol. Survey, 1883, p. 512.

Until 1888 South Carolina enjoyed a monopoly of the phosphate industry of the United States. In that year Florida came forward as a phosphate State, with a production of 3,000 long tons. In 1904 the production surpassed that of South Carolina, and Florida has maintained its lead up to the present time.

In 1892 phosphate was discovered in Tennessee, and two years later the production from that State was 19,188 long tons. In 1899 Tennessee went ahead of South Carolina, the production from the latter State having decreased steadily since 1894.

PRODUCTION.

The production of phosphate from South Carolina from the beginning of the industry in 1867 to the year 1888, during which period that State was the only producer, was 4,442,945 long tons, valued at $23,697,019. The following table shows the total production from the United States from 1867 to 1907:

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1867-1887	4,442,945	$23,697,019	1899	1,515,702	$5,084,076
1888	448,567	2,018,552	1900	1,491,216	5,084,248
1889	550,245	2,937,776	1901	1,483,723	5,316,403
1890	510,499	3,213,795	1902	1,490,314	4,693,444
1891	587,988	3,651,150	1903	1,581,576	5,319,294
1892	681,571	3,296,227	1904	1,874,428	6,580,875
1893	941,368	4,136,070	1905	1,947,190	6,763,403
1894	996,949	3,479,547	1906	2,080,957	8,579,437
1895	1,038,551	3,606,094	1907	2,265,343	10,653,558
1896	930,779	2,803,372			
1897	1,039,345	2,673,202	Total	29,208,141	117,316,002
1898	1,308,885	3,453,460			

Of this amount South Carolina has furnished 11,912,959 tons; Florida, 12,395,731 tons; Tennessee, 4,859,991 tons; and other States, 40,460 tons. In twenty years Florida has produced more phosphate than has South Carolina in thirty-one years.

GEOLOGIC OCCURRENCE.

The phosphate deposits range in age from the Ordovician in Tennessee to the Tertiary in Florida, occurring also in the Devonian in Tennessee and Arkansas, and in the Carboniferous in the Wyoming-Idaho-Utah field.

FLORIDA DEPOSITS.

DISTRIBUTION.

Phosphates occur in a general way along the west coast of Florida, principally in Polk, De Soto, Hillsboro, Pasco, Hernando, Sumter, Citrus, Marion, and Levy counties, although the rock has been found also in Alachua, Suwanee, Lafayette, Taylor, Jefferson, Wakulla, and Liberty counties. There are three classes of deposits in Florida—hard rock, land pebble, and river pebble. These deposits vary in percentage of tricalcium phosphate from 78 per cent to 80 per cent in the hard rock, through 68 per cent to 70 per cent in the land pebble, to about 65 per cent in the river pebble.

Hard rock.—The hard-rock phosphate belongs to the Eocene and the Miocene periods. In the former it consists entirely of a bowlder deposit in a soft matrix of phosphatic sands, clays, and other materials, while in the latter it is also found at many places as a bedded deposit in situ. The bowlders vary in size from 2 or 3 inches to 8 or 10 feet, and lie embedded in all positions, surrounded by sand and clay containing more or less phosphate of lime in finer particles, resulting from a general distribution of the disintegrated portions of the bowlders during deposition. The deposits themselves vary from small pockets to those several acres in extent. The phosphate content of this class of deposits is from 10 per cent to 30 per cent of the mass.

Land pebble.—The pebbles making up this deposit range from minute size to that of a walnut. They are originally white in color, but become dark colored when subjected to water action. They are embedded in sand and are underlain by a stratum of tough, stiff, clayey material known as "bed rock." Above the deposit is an overburden from 1 to 25 feet thick consisting of sand and limestone bowlders. The proportion of phosphate to other rock of this class of deposits varies from 1 to 10 to 1 to 4, or from 10 per cent to 25 per cent.

River pebble.—This class of deposit is very similar to the land pebble and derives its name from its manner of occurrence in the river beds. The pebbles are white to dark brown in color and of about the same size as the land pebbles. They occur in the form of bars in the rivers, and are derived from the formations through which the river flows.

DEVELOPMENT AND PRODUCTION.

The year 1887 marked the beginning of the phosphate industry in Florida. In 1888 the first shipment of pebble phosphate from Peace River was made to Atlanta, Ga. In 1889 the hard-rock phosphate was discovered in Marion County, and in 1890 the land-pebble area was opened up in Polk County. The growth of the industry has been rapid and remarkable, until now Florida is the largest producer of phosphate rock in the United States.

The first production consisted of 3,000 tons in 1888, and twenty years later the output for the year was 1,357,365 tons, or nearly 60 per cent of the entire production of the United States in 1907. Following is a table showing the marketed production and value of phosphate rock from Florida, by years, since the first shipment:

Output of phosphate rock in Florida, based on marketed product, 1888–1907.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1888	3,000	$21,000	1899	726,420	$2,804,061
1889	4,100	28,000	1900	706,243	2,983,312
1890	46,501	338,190	1901	751,996	3,159,473
1891	112,482	703,013	1902	785,430	2,564,197
1892	287,343	1,418,418	1903	860,336	2,988,824
1893	438,804	1,979,056	1904	1,072,951	3,974,304
1894	527,653	1,666,813	1905	1,194,106	4,251,845
1895	568,061	2,112,902	1906	1,304,505	5,585,578
1896	495,199	1,547,353	1907	1,357,365	6,577,757
1897	552,342	1,493,515			
1898	600,894	1,847,796	Total	12,395,731	48,043,407

SOUTH CAROLINA DEPOSITS.

DISTRIBUTION.

The South Carolina phosphate beds occur interruptedly along a belt the lower limit of which extends along a meandering line from a point near the source of the Wanda River in Charleston County to the mouth of the Broad River. The belt follows the coast, running back as far as 20 miles from the ocean.

In South Carolina the phosphate rock occurs in two forms: The land rock and the river rock, running about 58 and 55 per cent in tricalcium phosphate.

Land rock.—The land rock is very probably of Miocene age, and consists of so-called pebble rock which is in fact a solid mass from which the calcium carbonate has been leached out and partially replaced by phosphate, leaving cavities which connect and penetrate through the rock, giving it the appearance of being made up of separate pebbles. The rock runs from 1 to 3 feet in thickness, and is overlain by a greensand marl.

River rock.—The river rock is so called because it is mined from the river channels. It consists essentially of the water-rounded fragments of the land rock.

DEVELOPMENT AND PRODUCTION.

As already stated, phosphate rock was discovered in South Carolina in 1867, during which year 6 tons were marketed. From this time on the production increased until 1889, when it amounted to 541,645 long tons. Since 1893 the production has almost steadily decreased, and in 1899 Florida took the lead in the industry. In 1907 only 257,221 tons were marketed from South Carolina. The total production and value of phosphate rock from South Carolina, by years, from 1867 to 1907, is shown in the following table:

Production of marketed phosphate rock in South Carolina, 1867–1907.

Year ending—	Quantity.	Value.
May 31—	*Long tons.*	
1867	6	
1868	12,262	
1869	31,958	
1870	65,241	
1871	74,188	
1872	58,760	
1873	79,203	
1874	109,340	$7,248,380
1875	122,790	
1876	132,478	
1877	163,000	
1878	210,322	
1879	199,365	
1880	190,763	
1881	266,734	1,980,259
1882	332,077	1,992,462
1883	378,380	2,270,280
1884	431,779	2,374,784
1885	395,403	2,339,468
December 31—		
1885	277,789	1,805,629
1886	430,549	1,848,939
1887	480,558	1,836,818
December 31—Continued.	*Long tons.*	
1888	448,567	$2,018,552
1889	541,645	2,892,276
1890	463,998	2,875,605
1891	475,506	2,948,138
1892	394,228	1,877,709
1893	502,564	2,157,014
1894	450,108	1,745,576
1895	431,975	1,411,032
1896	402,423	1,181,649
1897	358,280	986,572
1898	399,884	1,107,272
1899	356,650	1,078,099
1900	329,173	1,041,970
1901	321,181	961,840
1902	313,365	919,725
1903	258,540	763,803
1904	270,806	861,317
1905	270,225	878,169
1906	223,675	817,068
1907	257,221	980,867
Total	11,912,959	53,221,272

TENNESSEE DEPOSITS.

DISTRIBUTION.

The deposits of phosphate in Tennessee lie mainly in Maury, Hickman, Perry, and Lewis counties, with some deposits in Giles, Williamson, Davidson, Sumner, and Decatur counties.

There are three commercially important classes of phosphate rock in Tennessee: The brown residual phosphate, the blue or black bedded phosphate, and the white phosphate. These range in phosphatic content from 70 per cent to 80 per cent lime phosphate in the brown rock to 75 to 85 per cent lime phosphate in the white rock, although in all three classes are to be found portions which run as high as 90 per cent.

BROWN RESIDUAL PHOSPHATE.

This variety of phosphate occurs mainly in Maury County. It is of Ordovician age, and is the result of the leaching process to which the phosphatic limestones have been subjected. Surface waters bearing carbonic and other organic acids have dissolved and carried away a large part of the calcium carbonate forming the limestone, leaving the calcium phosphate as a residual deposit. The brown phosphate is from 2 to 6 or 8 feet in thickness at various points.

BLUE OR BLACK BEDDED PHOSPHATE.

These deposits are of Devonian age, and show variations from oolitic through compact and conglomeratic to shaly forms. There is also a nodular variety which occurs in a greensand formation immediately overlying the black shale. The bedded deposit occurs in seams varying from 1 to 50 inches in thickness, but where carrying high-grade rock the bed is seldom more than 20 inches thick. The phosphatic content ranges from 30 to 85 per cent. The nodular variety, which is embedded in a greensand matrix, runs about 60 per cent lime phosphate, but it is not practicable to work it except at points where the bedded rock is mined by stripping off the over burden.

WHITE PHOSPHATE.

This rock is of post-Tertiary age, and occurs in three different forms, stony, brecciated, and lamellar. The stony phase contains usually only about 50 per cent of lime phosphate and is not worked at the present time. The lamellar forms were deposited in caves, and are thus of irregular shape and extent. The breccia consists of fragments of Carboniferous chert cemented by lime phosphate. The chert fragments vary from a fraction of an inch to 3 or 4 inches in diameter. The lamellar variety consists of thin parallel layers or plates about 1 inch thick, but several inches long and broad.

The white phosphate has thus far been found only in Perry and Decatur counties. It runs sometimes as high as 85 per cent phosphate of lime.

DEVELOPMENT AND PRODUCTION.

The blue bedded phosphate of Tennessee was discovered in 1893 and was mined until 1896, when the brown rock was found to be valuable. The favorable location of this brown rock led to the cessation of blue-rock mining for the time. The white rock has not as yet been extensively mined.

The total production of phosphate rock from Tennessee from the first operations in 1894 to the end of 1907 is as follows:

Production of marketed phosphate rock in Tennessee, 1894–1907.

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Long tons.			*Long tons.*	
1894	19,188	$67,158	1902	390,799	$1,206,647
1895	38,515	82,160	1903	460,530	1,543,567
1896	26,157	57,370	1904	530,571	1,745,054
1897	128,723	193,115	1905	482,859	1,633,389
1898	308,107	498,392	1906	547,677	2,147,991
1899	424,109	1,177,160	1907	638,612	3,047,836
1900	454,491	1,328,707			
1901	409,653	1,192,090	Total	4,850,991	15,920,636

ARKANSAS DEPOSITS.

The developed phosphate deposits of Arkansas are on Lafferty Creek, on the western edge of Independence County. The rock itself is light gray, homogeneous, and conglomeratic, with small pebbles more or less angular in form. The phosphate bed runs from 2 to 6 feet in thickness, and varies from 25 to 73 per cent phosphate of lime.

DEVELOPMENT AND PRODUCTION.

The Arkansas phosphates as such were discovered in 1895, but it was not until 1900 that any attempt was made to develop them. At that time the Arkansas Phosphate Company was formed, and a mining and milling plant was erected. After only a few months' operation this plant was destroyed by fire, and it has only been within the last two years that any production has been marketed, and that has been a small one. Analyses show that very little of this rock is high grade, and the field will probably not be operated until 30 to 50 per cent rock can be utilized.

WYOMING-IDAHO-UTAH DEPOSITS.

DISTRIBUTION.

Within the last few years a large area of phosphate-bearing rock has been discovered in the western United States. This discovery is of much importance since it opens a new field in an area which is tributary to the great agricultural region of the Middle West. The phosphate occurs over a considerable area in southeastern Idaho, southwestern Wyoming, and northeastern Utah. It is found in rocks of upper Carboniferous age in a series of shales and limestones, 100 feet thick, within which are several beds of phosphate rock ranging in thickness from a few inches to 10 feet. At the base of the series is a limestone, and 6 to 8 inches of soft brown shale separates this from the principal phosphate bed, which is 5 to 6 feet thick. This phosphate bed is oolitic in character and high in phosphoric acid. There are several other beds ranging from a few inches to 10 feet in thickness, separated by thin beds of limestone or shale, in the series. Usually one and sometimes two of these beds at a given section are workable, and probably some of the others will eventually be mined. The lime phosphate content in the workable beds varies from 65 to 80 per cent, with an average of 72 per cent.

DEVELOPMENT AND PRODUCTION.

The newness of the field, the lack of transportation facilities, and the high freight rates have prevented the development of this phosphate territory to a great extent, although there has been some shipment from Montpelier, Idaho, in the last two years. According to F. B. Weeks,[a] who recently prepared a report upon these phosphates:

> This field embraces the largest area of known phosphate beds in the world, and at some future time it will doubtless furnish a large part of the world's production of commercial fertilizer. The development of intensive farming as a result of the reclamation of arid lands in the West will afford an increasing home market.

PHOSPHATE AS A FERTILIZER.

According to a letter from Dr. W. L. Rasin, of Baltimore:[b]

> The manufacture of chemical fertilizers in the United States began about 1850. In that year Dr. P. S. Chappell and Mr. William Davison, of Baltimore, made some fertilizer in an experimental way. About the same time Professor Mapes was experimenting. Later De Burg utilized the spent bone black derived from the sugar refineries and made quite a quantity of "dissolved bone black" (superphosphate). In 1853 or 1854 Dr. P. S. Chappell commenced the manufacture of fertilizers, as did B. M. Rhodes, both of Baltimore. In 1855 Mr. John Kettlewell, recognizing the fact that Peruvian guano (then becoming quite popular and containing at that time 18 to 21 per cent ammonia) was too stimulating and deficient in plant food (phosphates), conceived the idea of manipulating the Mexican guano, containing no ammonia but 50 to 60 per cent of (bone) phosphate of lime, and called his preparation "Kettlewell's manipulated guano."
>
> While in 1856 the sales of Peruvian guano had increased to 50,000 tons, and of Mexican guano to some 10,000 tons, there was not at that date 20,000 tons of artificial fertilizers manufactured in the entire country. Baltimore was not only the pioneer but the principal market for fertilizers until some time after the civil war.

In 1859 a fertilizer plant was built at Charleston, S. C., by Professor Shepard and Col. L. M. Hatch, but it was soon abandoned. Since the discovery of valuable deposits of phosphate rock in South Carolina in 1867, the fertilizer industry has grown rapidly, and in 1900 there were 478 factories in the United States, with an output of 2,887,004 tons of fertilizer, valued at $41,997,673.

AVAILABLE PHOSPHATE DEPOSITS.

The known phosphate deposits of the United States are distributed principally among four localities: (1) Along the west coast of Florida, going back 20 to 25 miles inland; (2) along the coast of South Carolina, extending 6 to 20 miles inland; (3) in central Tennessee; and (4) in an area comprising southeastern Idaho, southwestern Wyoming, and northeastern Utah. In addition to these areas some deposits occur in north-central Arkansas, along the Georgia-Florida state line, in North Carolina, Alabama, and Mississippi, but these are mainly of low grade and not utilized at the present time. The first three of the important deposits have been worked for ten to thirty years, while the fourth is a new field which has as yet had but a small output.

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[a] Contributions to economic geology, 1907, pt. 1: Bull. U. S. Geol. Survey No. 340, 1908, pp. 441-447.

[b] Twelfth Census Report, Vol. X, Pt. IV, p. 562.

Owing to very incomplete data any estimate as to available supply of phosphate rock must, at best, be unsatisfactory. Taking South Carolina as the field most likely to first reach the exhaustion point, Florida second, Tennessee third, and the practically untouched deposits of Idaho-Wyoming-Utah last, an estimate of the available supply and possible duration is given, based on the past production.

South Carolina.—By reference to the table of total production (p. —) it will be seen that the output gradually increased from 1867 until 1889, when the largest production, 541,645 long tons, was marketed. Since 1893 the output has decreased at about the same rate as the increase previous to that year. In the twenty-seven years from 1867 to 1893 the production was 7,269,453 long tons, and in the fourteen years since 1893 the production has been only 4,643,506 tons, or 63.8 per cent of the production to 1893. Arguing from these figures, it is safe to say that the amount of phosphate rock remaining to be mined in South Carolina is not more than 3,000,000 tons, but it is possible that by careful deeper prospecting these figures may be increased. At the present rate of production this field has a probable life of not more than fifteen years.

Florida.—The total production of phosphate rock in Florida since the beginning of the industry in 1888 has been 12,395,731 tons. As shown by the table on page 560 there has been a steady increase in production, but since 1904, when the increase in output over the previous year was 212,615 tons, the increase has been smaller each year, until in 1907 it was only 52,860 tons. When it is remembered that the phosphate deposits in Florida are not continuous beds, but rather pockets, and that practically all the phosphate-bearing areas in the State have already been discovered, it appears conservative to estimate an available supply remaining at not more than 15,000,000 tons, or a little more than has already been produced. At the present rate of production the phosphates of Florida would have a life of approximately twelve years.

Tennessee.—The total production of phosphate rock in Tennessee since the discovery in 1893 has been 4,859,991 tons. In 1907 the production was the largest in the State's history, amounting to 638,612 tons. In Tennessee the phosphates exist as brown rock, blue bedded rock, and white rock. The brown rock is the result of leaching processes in an original phosphatic limestone and occurs usually on the surface. The ease of mining and accessibility to transportation have contributed to the rapid working out of this class of rock, but there still remains enough of it to last possibly five years at the present rate of production; that is, about 3,000,000 tons. The blue bedded rock has not been worked considerably in the past, but with the approaching exhaustion of the brown rock a good deal of activity is now being shown. The bedded character of this rock and its continuity over large areas make it certain that large amounts are still available. According to the American Fertilizer for November, a company has been organized and has taken up 16,375 acres of phosphate land, with 10,000 acres under option. An estimate of 1,500 tons to the acre gives approximately 40,000,000 tons, but this estimate is very conservative. The phosphate rock is heavy, weighing about 175 pounds to the cubic foot. Supposing workable phosphate rock 1 foot in thickness to underlie the 26,375 acres, there would be approximately 100,500,000 tons as an available supply in this territory, more than two and one-half times the amount estimated by the American Fertilizer. With the 3,000,000 tons of brown rock estimated, there would be a total available supply of 103,500,000 tons remaining in Tennessee. At the present rate of production in Tennessee this would last about 160 years. But with the exhaustion of the South Carolina and Florida deposits in twelve years the burden of the industry would fall on Tennessee and the western deposits. In case Tennessee furnished all the phosphates for the country, at the present rate of total production, after the South Carolina and Florida deposits are exhausted in twelve years, the Tennessee deposits would give out about 1960. These figures do not include vast quantities of rock running from 25 to 50 per cent lime phosphate, which are not at present workable.

Wyoming-Idaho-Utah.—The production from this field has not been sufficient to warrant mention, nor has enough detailed work been done in the area to afford a good basis for figuring available supply.

F. B. Weeks, of the Geological Survey, has made a reconnaissance report on the district, from which a very rough estimate of the available rock may be made. The phosphate formation consists of phosphatic limestones and shales 80 to 100 feet in thickness, varying in lime phosphate from 65 to 80 per cent in the workable beds to 20 to 50 per cent in the portion not at present workable. This series dips at all angles from 20° to 90°, thus giving a much larger possible tonnage than would be expected from the superficial extent of the deposits. The formation is cut by faults to a very great extent.

The area underlain by phosphate in the western field is almost wholly public land. Only one claim, the Waterloo placer claim, has been patented, but much land valuable for its phosphate deposits has been staked out in claims, of which there are not to exceed 200 in the aggregate. The engineer of the Waterloo property claims 1,000,000 tons of rock in sight above the valley, without taking into consideration the rock underground where the steep dip carries it from the mountain side. There are perhaps 200 other claims on which development work is being done at the present time. If each of these claims is but half as rich as is the Waterloo, they would represent an available supply of 100,000,000 tons in this field, a supply sufficient to furnish the entire production of the United States, based on the 1907 output, for forty-four years. It is to be understood that these figures do not include the immense quantities of low-grade rock which underlie the western field, nor do they take into consideration the quantities which are at present too deep to be profitably worked. With no more reliable figures at hand, this estimate is offered for the high-grade phosphate rock at present actually available in the Wyoming-Idaho-Utah field. Doubtless before the high-grade rock is exhausted some method will be devised for making use of the low-grade rock, which is at present unavailable both in Tennessee and the West.

Arkansas.—Phosphate deposits are known to occur in Arkansas, but they have not been mined to any large extent. They are apparently of low grade, and large quantities are not to be counted on until rock containing 30 to 50 per cent lime phosphate can be utilized for fertilizer manufacture. This material would not, therefore, be classed as available at this time.

EXPORTATION.

In 1907 there were 2,265,000 tons of phosphate rock produced in the United States. Of this amount over 900,000 tons, or about 40 per cent, was exported. It is not difficult to see that, with our steadily increasing population, the time is not very far distant when the farm lands of the Middle West will be burdened to their fullest capacity. It has been shown, as the result of agricultural experiment station work in Wisconsin, Ohio, and Illinois, that in fifty-four years soils of these States in the cropped areas have been depleted of one-third of their original phosphoric acid. This is equivalent to 20 pounds per acre annually. Assuming it to be only half this amount for the 400,000,000 acres of cropped land in the United States, it would require 6,000,000 tons of phosphate rock annually, or nearly three times our 1907 production, to offset this loss, without considering the question of increasing the productivity. With the reclamation of the arid lands of Wyoming and other Western States will come a period of intensive farming, and in order to produce the large crops which will be required of them, these lands must soon have the assistance of artificial fertilizer. We will have enough to do to take care of our own farm lands without shipping our phosphate rock to foreign countries, and in justice to future generations exportation should be stopped.

Total tonnage available.—Following is a table showing the estimated tonnage of phosphate rock available at the present time in the United States.

	Tons.
South Carolina	3,000,000
Florida	15,000,000
Tennessee	103,500,000
Western States	100,000,000
Total	221,500,000

ESTIMATED LIFE OF PHOSPHATE DEPOSITS.

The rate of increase in production for the past twenty years has been 117 per cent for each decade. Assuming that this rate of increase will continue, it will require just twenty-five years to exhaust the available supply of phosphate rock in the United States. The annual production, at the above rate of increase, will be approximately 17,000,000 tons in 1932.

It is hardly probable that the rate of increase in production will be so great as for the past decade, since the agricultural lands of the Middle West do not at present need artificial assistance. But increasing population with its accompanying intensive farming will eventually force these States to the use of fertilizing materials. The reclamation of arid lands in the West will probably postpone the day, but even those lands will early need some assistance to grow the large crops which will be required of them.

Of course the vast amount of low-grade rock which is not now available will be in reserve, and sometime before the exhaustion of the high-grade phosphates we will doubtless have begun to use this rock. The increasing price of the 60 to 80 per cent phosphate will have a hastening effect on the utilization of the present low-grade material. We have the deposits of Arkansas, Georgia, North Carolina, Alabama, Tennessee, and the West, which run from 30 to 50 per cent in lime phosphate, to draw upon after the high-grade rock is exhausted. This class of deposits, especially in Tennessee and the Western States, will afford an enormous tonnage.

There is still the chance of the discovery of more phosphate fields, and probably the Wyoming-Idaho-Utah field will produce far more than estimated, but based upon present available deposits the life of the phosphates must at best be a short one.

FOREIGN DEPOSITS.

Deposits of phosphate rock exist in Algeria, France, New Zealand, Canada, Russia, Spain, Tunis, Belgium, French Guiana, and some of the South Sea Islands. The deposits of France and Belgium are practically exhausted, only those of low grade remaining. Concerning the other countries, no information as to reserve tonnage is at hand except for the three South Sea Islands—Ocean, Pleasant, and Makatea. These islands have deposits which are estimated to contain an aggregate of 60,000,000 tons of high-grade phosphate rock.

UTILIZATION OF THE PHOSPHATES.

From the above figures it will at once be seen that the utilization of our phosphate deposits to the best possible advantage is imperative. Our farm lands must be preserved for future generations. The phosphate rock of South Carolina is practically exhausted; the Florida deposits have reached their maximum production; the output of the Tennessee deposits is on the increase, but this field alone would, at the present rate of increase in production, last only eleven years. There is some phosphate in Arkansas, but it is of low grade; therefore the large deposits of the public-land States must be depended on for the greater part of our phosphate in the future. The conservation of our phosphate deposits can be best accomplished in the following ways:

1. *Correction of wasteful mining methods.*—The waste involved in mining phosphates, especially in Tennessee, should have some attention. In order to get the largest quantity of high-grade rock necessary for the export trade, large amounts of 50 per cent rock are thrown on the dump and wasted. The time is sure to come when 50 per cent rock, and even 25 per cent rock, will be utilized in fertilizer manufacture. Steps should be taken now to prevent this waste in order to avoid a similar mistake when the phosphates of the Western States are mined. Much of the western rock runs from 25 to 50 per cent lime phosphate, and such material should be saved toward the

time when the term "high-grade rock" will come to mean a lime phosphate content of 40 to 50 per cent instead of 70 to 80 per cent as at present.

2. *Utilization of sewage.*—One of the important sources of phosphoric acid to which we must look in the future is the human excrement which is now being wasted through the present systems of sewage disposal. Van Hise says:

> Whitson estimates that the loss in the cities due to man alone is the equivalent of 2 or 3 pounds of phosphoric acid per acre for the entire cropped region of the United States. Supposing this loss to be 2 pounds, this is one one-thousandth of a ton, which amounts for the 400,000,000 acres to 400,000 tons of phosphoric acid, or equivalent to 1,200,000 tons of phosphate rock.

The significance of these figures will at once be seen when it is known that the total production of phosphate rock in the United States for the year 1907 was 2,265,343 tons.

3. *Leasing of the phosphate deposits.*—Only by preventing or materially curtailing exportation can we be assured of the use of our phosphate deposits for our own lands in the future. The following table shows the production and exportation of phosphate since 1900:

Table showing production and exportation of phosphate rock in the United States, 1900–1907.

Year.	Production.	Exportation.	Year.	Production.	Exportation.
	Long tons.	*Long tons.*		*Long tons.*	*Long tons.*
1900	1,491,216	776,220	1905	1,947,190	879,979
1901	1,483,723	624,996	1906	2,080,957	964,241
1902	1,490,314	747,672	1907	2,265,343	900,983
1903	1,581,576	817,503			
1904	1,874,428	849,130	Total	14,214,747	6,560,724

From this table it will be seen that over 46 per cent of the phosphate rock produced in the United States since 1900 has gone to foreign countries. In this connection the American Fertilizer for November gives an account of the organization of the Franco-American Consolidated Phosphate Company, with a capitalization of $7,500,000. The capital stock is fully paid up, and is divided as follows: $5,250,000 for the purchase of phosphate lands in Tennessee, and $2,250,000 for the purchase of fertilizer plants in Europe and for working capital. The company is headed by a powerful syndicate of leading fertilizer manufacturers and bankers of France, Spain, Italy, and Belgium, who will control the stock of the company; and by this organization the fertilizer industry of Europe is expected to be completely under its control.

The company has purchased 16,375 acres of phosphate lands, and has 10,000 acres more under option. Among their plans it is stated:

> The company has contracted all of the export rock it can produce for the next ten years, and has concluded arrangements for the immediate introduction, on a large scale, of the blue rock, both in Europe and in this country.

From this it would appear certain that the phosphate deposits of the United States are to be drained for the benefit of the worn-out farm lands of foreign countries. So far as the deposits of Florida, Tennessee, and South Carolina are concerned, this can not be easily prevented, but the production of the newly opened western fields may be preserved for the United States by retaining in the Government title to all the phosphate rock in the lands now belonging to the United States, and leasing these deposits under appropriate terms. In the lease could be included a clause providing that the lessee shall agree to mine phosphate rock only for home consumption.

If all the lands containing phosphate were reserved pending leasing, it would remove from entry certain lands which might otherwise be occupied by home seekers, and it is therefore necessary to provide for the disposal of surface rights alone. Such a separation of surface and mineral rights would obviate the necessity of creating large phosphate reserves in which the surface lands would be removed from settlement; it would permit the fullest utilization of the land in all particulars. A separation of surface and mineral rights would furthermore insure the proper utilization of all phosphate deposits which may hereafter be found in lands now belonging to the United States.

TENURE OF MINERAL LANDS.

By C. W. Hayes,
United States Geological Survey.

There is unquestionably a strong tendency toward the segregation of mineral properties; it is stronger, however, in connection with some minerals than with others. The tendency is probably greatest in connection with iron ores. The reasons are that the iron-making industry itself has in recent years been consolidated under the control of a comparatively few companies, and these companies have in most cases pursued the policy of securing their own ore reserves. Thus the Steel Corporation probably controls 75 per cent of the iron ore in the Lake Superior and southern Appalachian districts.

The tendency to segregate is less strongly marked in the case of coal. This appears to be due chiefly to the fact that coal mines may be developed on comparatively small capital, and to the further fact that the market for the product is very widely disseminated, whereas iron ore, even when produced independently of the companies owning the furnaces, is disposed of to a relatively few purchasers.

Intermediate between iron ore and coal are deposits of the precious and semiprecious metalliferous ores. The extent to which these are segregated in a few hands is determined largely by the geographic position, although the character of the ore and the necessity for obtaining suitable furnace mixtures is also a factor.

The tendency to segregate in case of the minor minerals is not strong. Thus the production of barite, mica, corundum, graphite, feldspar, pyrite, manganese, etc., comes from a large number of small independent producers. The production of sulphur in this country is a monopoly, not by reason of the segregation of separate properties, but through the possession of a patented method for extracting the sulphur from the deposit. An attempt was made to secure control of the production of salt, but the movement failed. The production of petroleum has remained in a large number of separate companies chiefly because such a condition was most satisfactory to the principal refining companies.

MINERAL RESOURCES OF ALASKA.

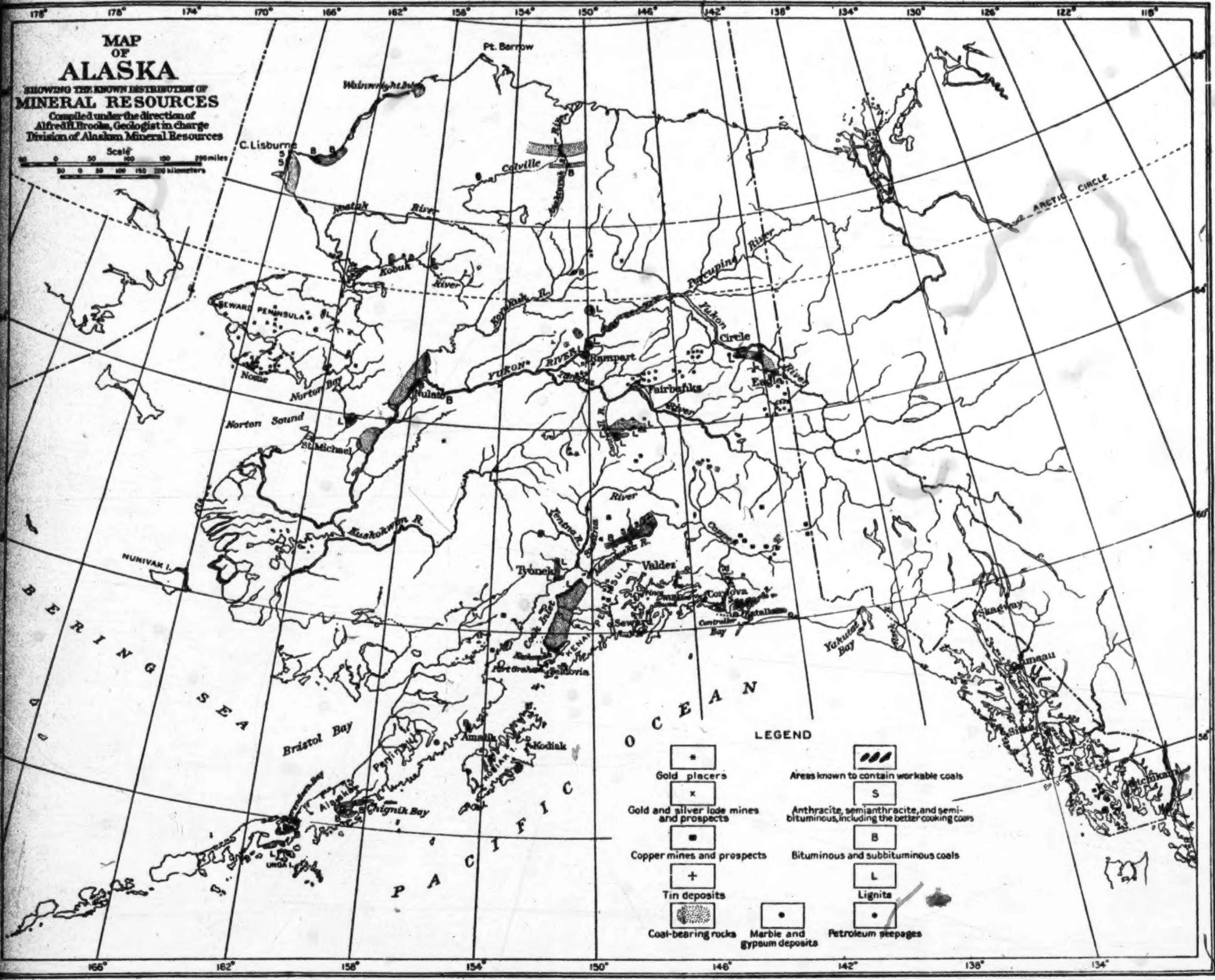
By Alfred H. Brooks,
Geologist in charge, Division of Alaskan Mineral Resources, United States Geological Survey.

INTRODUCTION.

A complete description of the mineral resources of any region is possible only when its geology has been exhaustively studied, and even then any quantitative determination of the mineral reserves is often little more than a bold guess. The Alaskan geologic surveys and investigations, begun a decade ago, now cover but 16 per cent of the entire Territory. These, moreover, for the most part have been of a preliminary character, and, while they have yielded important facts regarding the occurrence and distribution of the mineral deposits, they do not furnish the minute knowledge essential to quantitative determination. Detailed surveys and studies such as have been relied on elsewhere for quantitative data on mineral deposits are in Alaska almost entirely lacking, since less than a third of 1 per cent of its area has been subjected to such investigation. Therefore, as 84 per cent of the Territory is geologically almost unknown and less than 1 per cent has been mapped in detail, it will be evident that this statement can be only of a very general character.

The following account of the mineral resources of Alaska is based entirely on the work of the United States Geological Survey, whose reports furnish almost the only sources of information on this subject. In the preparation of this statement the writer has utilized the results of all the geologists and engineers who have worked in this field, and has received valuable assistance from G. C. Martin, C. W. Wright, L. M. Prindle, F. J. Katz, U. S. Grant, C. C. Covert, F. F. Henshaw, P. S. Smith, F. H. Moffit, and Adolph Knopf.

In the lack of comprehensive quantitative data it will probably best serve the purposes of this report to consider the more general problems of geographic and geologic occurrence of the various useful minerals of the Territory. The coal resources will be considered at some length, both because of the importance of the mineral fuel reserves and because the geologic occurrence of coal is such as to permit a quantitative interpretation of the data with a far greater degree of assurance than of those relating to other mineral deposits. The subject of iron ore reserves, of almost equal importance with that of coal, can be but briefly touched upon, because so few facts regarding it are available. But little attention has been devoted to iron ore



MAP OF ALASKA

SHOWING THE KNOWN DISTRIBUTION OF MINERAL RESOURCES

Compiled under the direction of Alfred H. Brooks, Geologist in charge Division of Alaskan Mineral Resources

Scale
50 0 50 100 150 200 miles
50 0 50 100 150 200 kilometers
LEGEND
Gold placers
Gold and silver lode mines and prospects
Copper mines and prospects
Tin deposits
Coal-bearing rocks
Marble and gypsum deposits
Areas known to contain workable coals
S
Anthracite, semianthracite, and semibituminous, including the better cooking coals
B
Bituminous and subbituminous coals
L
Lignite
Petroleum seepages
Pt. Barrow
Wainwright Inlet
C. Lisburne
Colville
Noatak River
Kobuk River
SEWARD PENINSULA
Nome
Norton Bay
Norton Sound
St. Michael
Nulato
Koyukuk R.
YUKON RIVER
Rampart
Tanana
Fairbanks
Porcupine River
Yukon River
Circle
Eagle
Kuskokwim R.
NUNIVAK I.
Tyonek
Cook Inlet
KENAI PENINSULA
Valdez
Cordova
Seward
Katalla
Controller Bay
Yakutat Bay
Skagway
Juneau
Sitka
Ketchikan
Port Graham
Seldovia
Kodiak
Bristol Bay
Alaska Peninsula
Chignik Bay
UNGA I.
BERING SEA
PACIFIC OCEAN
ARCTIC CIRCLE
178° 178° 174° 170° 166° 162° 158° 154° 150° 146° 142° 138° 134° 130° 126° 122° 118°
166° 162° 158° 154° 150° 146° 142° 138° 134°

by the Alaskan geologists, for there is not a single iron mine in the Territory and at only two localities have iron-ore bodies been prospected. Relatively much more is known about the auriferous deposits, especially the placers, for here the observation of the geologist is supplemented by the many facts developed in the course of mining and prospecting. But the character of these deposits, especially that of the auriferous lodes, makes estimates of mineral reserves of but little value. The same holds true of the copper deposits, which are of too great irregularity to allow even an approximation of the available tonnage. Moreover, though copper ores find a wide distribution in the Territory, they have been mined in only two districts. Most of the copper mines are not over 200 feet in depth, one only having reached 600 feet. Predictions as to permanency of ore bodies at depth in this field, which must form an important element in estimating tonnage, can therefore have no great value.

GENERAL DISTRIBUTION.

The ores and other minerals mined in Alaska up to the close of the year 1907 include gold, silver, copper, lead, tin, coal, petroleum, gypsum, marble, and mineral waters. In addition to these iron, tungsten, antimony, quicksilver, graphite, and peat have been found in deposits that will probably be exploited in the future. Of these only the deposits of gold, silver, copper, lead, iron, coal, petroleum, and peat will be described in this report.

As there are no political subdivisions of Alaska, it will be desirable to refer the distribution of its resources to certain geographic provinces, and these must first be defined. (See Pl. I.) The Pacific province includes the lode and placer districts of southeastern Alaska, the Controller Bay coal and petroleum fields, the copper lodes of Prince William Sound, the copper-bearing lodes and gold placers of the Copper River region, the gold placers and lodes and coal fields of the Susitna and Matanuska basins and of the Kenai Peninsula, and the coal fields and gold and copper lodes of the Alaska Peninsula and adjacent islands, often called southwestern Alaska. This whole coast province is a region of strong relief, and much of it is readily accessible from the waters of the Pacific, open to navigation throughout the year.

The mountain system included within the Pacific province forms a high barrier between the coast and the central province, which is of lesser relief. This central province, drained to Bering Sea by the Yukon, Kuskokwim, and some smaller rivers, includes the gold placers of the Yukon-Tanana region, the Koyukuk, and some smaller districts, as well as extensive deposits of lignitic coal. It is accessible in summer by river steamers, but in winter only by long sled journeys.

Seward Peninsula, forming a distinct province, embraces valuable gold placers, as well as some auriferous and argentiferous lodes, some tin deposits, and a little lignitic coal. It is accessible by steamer only during the summer months.

Northern Alaska is here made to include the high mountains which bound the central province on the north, as well as the region of lesser relief bordering the Arctic Ocean. This field has been but little explored, but it is known to contain some placer gold and bituminous as well as lignitic coal. It seems probable that further surveys will show the presence of extensive coal fields in northern Alaska.

These geographic subdivisions have an important influence on the question of the conservation of the mineral wealth of the Territory, for as the geographic conditions dominate the commercial exploitation of the resources, they determine in a large measure the rapidity with which these resources will become exhausted. For example, the lode deposits and coal fields readily accessible from the Pacific seaboard are being exploited for the use of the present generation. On the other hand, though the development of the placer fields of the central province began nearly a generation ago, large areas are still entirely unprospected, and the coal fields of the same region are almost entirely untouched. The coal fields of northern Alaska are not only entirely undeveloped, but are certain to remain so until the time in the future when the accessible coal of Alaska and the United States approaches exhaustion.

COAL.

[By Alfred H. Brooks and George C. Martin.]

STRATIGRAPHIC POSITION AND COMPOSITION.

The Alaskan coals include lignitic, bituminous (some of which will make good coke), and anthracite varieties. Of these the lignitic and lower-grade bituminous coals are the most widely distributed and, so far as now known, the most abundant, at least half of the known coals being lignites. To offset their lower fuel value the lignites often occur in thick beds and with a large percentage of coal in any given section. Moreover, their geographic distribution is such that they afford an important source of fuel for local consumption in some of the less accessible parts of the Territory.

These coals belong to four geologic periods, namely, Tertiary, Cretaceous, Jurassic, and Carboniferous. In addition to these there are some inferior lignites of Quaternary age, and it is by no means improbable that further investigation may lead to the discovery of coal at still other horizons. Of these four periods only the fuels of the first three promise to have any considerable commercial importance, and all but one of the important coal fields are of Upper Cretaceous or Tertiary age. In fact, a large part of the coal beds have been identified as belonging to the Kenai formation, whose age is believed to be upper Eocene. The Carboniferous and Jurassic coals vary in composition from semibituminous to subbituminous fuel. In the younger coal fields anthracite, various grades of bituminous, and lignitic coals are found.

The following table shows the composition of the coals from different parts of the Territory:

Analyses of Alaska coal.

[Compiled from reports of United States Geological Survey.]

District and kind of coal.	Moisture.	Volatile matter.	Fixed carbon.	Ash.	Sulphur.	Fuel ratio.
ANTHRACITE.						
1. Bering River, average of 7 analyses	7.88	6.15	78.23	7.74	1.30	12.86
2. Matanuska River, 1 sample	2.55	7.08	84.32	6.05	.57	11.90
SEMIANTHRACITE.						
3. Bering River, average of 11 analyses	5.80	8.87	76.06	9.27	1.08	8.77
SEMIBITUMINOUS.						
4. Bering River, coking coal, average of 28 analyses	4.18	14.00	72.42	9.39	1.73	5.28
5. Cape Lisburne, average of 3 analyses	3.66	17.47	75.95	2.92	.96	4.46
6. Matanuska River, coking coal, average of 16 analyses	2.71	20.23	65.39	11.60	.57	3.23
BITUMINOUS.						
7. Lower Yukon, average of 11 analyses	4.68	31.14	56.62	7.56	.48	1.90
SUBBITUMINOUS.						
8. Matanuska River, average of 4 analyses	6.56	35.43	49.44	8.57	.37	1.40
9. Koyukuk River, 1 sample	4.47	34.32	48.26	12.95	....	1.40
10. Nation River, 1 sample	1.39	40.02	55.55	3.04	2.98	1.39
11. Alaska Peninsula, average of 5 analyses	2.34	38.68	49.75	9.22	1.07	1.30
12. Cape Lisburne, average of 11 analyses	9.35	38.01	47.19	5.45	.35	1.24
13. Anaktuvuk River, 1 sample	6.85	36.39	43.38	13.38	.54	1.20
LIGNITE.						
14. Port Graham, 1 sample	16.87	37.48	39.12	6.53	.39	1.04
15. Southeastern Alaska, average of 5 samples	1.97	37.84	35.18	24.23	.57	1.02
16. Wainwright Inlet, 1 sample	10.65	42.99	42.94	3.42	.62	1.00
17. Colville River, 1 sample	11.50	30.33	30.27	27.90	.50	1.00
18. Upper Yukon, Canadian, average of 13 analyses	13.06	39.88	39.28	7.72	1.26	.99
19. Upper Yukon, Circle province, average of 3 analyses	10.45	41.81	40.49	7.27	1.30	.97
20. Upper Yukon, Rampart province, average of 6 analyses	11.42	41.15	36.95	10.48	.33	.91
21. Seward Peninsula, 1 sample	24.92	38.15	33.58	3.35	.68	.88
22. Chitistone River, 1 sample	1.65	51.50	40.75	6.10	....	.79
23. Kachemak Bay, average of 6 analyses	19.85	40.48	30.99	8.68	.35	.77
24. Nenana River, 1 sample	13.02	48.[illegible]	32.40	5.77	.16	.66
25. Kodiak Island, 1 sample	12.31	51.[illegible]	33.80	2.41	.17	.66
26. Unga Island, average of 2 analyses	10.92	53.3[illegible]	28.25	7.47	1.36	.62
27. Tyonek, average of 4 analyses	8.35	54.20	30.92	6.53	.38	.56
28. Chistochina River, 1 sample	15.91	60.35	19.46	4.28	....	.32

DISTRIBUTION AND AREA.

The known coal-bearing areas aggregate some 1,202 square miles, while the estimated areas of the coal fields are 12,667 square miles (see p. 581). The distribution of the coal, together with a symbol indicating its quality, is shown on the accompanying map.

Besides showing the actual distribution of the areas believed to be underlain by workable coal beds (marked in black) the map also shows the areas of the coal fields, so far as they are known (marked by stippling). The difference in what is represented by these two symbols is that in the first are included areas in which there is a reasonable degree of certainty that commercial coal beds can be opened up, while the second indicates what is known of the probable extension of the coal fields, and hence defines the areas worthy of prospecting. It should be noted that this mapping does not by any means have the same value throughout the territory, for in some instances it is based on geologic surveys of a high degree of refinement; in others the data include only observations made during a rapid reconnaissance.

The coal fields can be considered under the three general geographic provinces already described: (1) The Pacific slope, (2) the central region, and (3) the northern region. (See map.) In the first are included the lignitic and bituminous fields of southeastern Alaska, Cook Inlet, the Susitna Basin, and the Alaska Peninsula, as well as the high-grade fuels of the Controller Bay and Matanuska regions. About 40 per cent, both of the area known to be underlain by coal and of the estimated area of the total coal fields of the Territory, falls in this province. It includes also at least 90 per cent of the known bituminous and higher-grade coals of the Territory. In considering this percentage of total coal area it must be remembered that this is the best-known part of the Territory, and there is, therefore, less likelihood of future discoveries of coal than in the less explored districts of central and northern Alaska. However, as over 50 per cent of this province is geologically almost unknown, there are possibilities that future surveys may lead to the discovery of more extensive coal-bearing areas.

The central province includes some bituminous and subbituminous coals on the lower Yukon, besides more extensive lignitic coal-bearing fields in the upper Yukon basin, near the coast line of Bering Sea, and elsewhere. Thirty-five per cent of the total known coal-bearing area falls in this province, and about 36 per cent of the estimated coal fields. At least 80 per cent of the central province, however, is almost unknown, so it is likely that further discoveries of coal will there be made.

The northern region includes the bituminous and subbituminous coals of the Cape Lisburne region, as well as lignitic and bituminous coal-bearing rocks in the Colville basin. These fields aggregate 24 per cent of the coal area of the Territory, and the area known to be underlain by coal forms 25 per cent of the total. This is a remarkable showing, in view of the fact that only about 10 per cent of this province has been studied geologically. There is every reason to believe that there are extensive coal fields in this part of Alaska.

THE COAL FIELDS.

SOUTHEASTERN ALASKA.

Though Tertiary (or possibly Upper Cretaceous) coal-bearing rocks are known to cover a considerable area on the southern part of Admiralty Island and on adjacent islands, the included coal beds have only a remote fuel value. The beds are from a few inches to 2 or 3 feet in thickness, and the coal, so far as known, is of a low-grade lignitic character.

BERING RIVER.

One of the two fields containing the largest known amount of high-grade coal lies about 25 miles northeast of the small indentation of the southern shore line of Alaska called Controller Bay. The field is drained by Bering River, from which it received its name. This

Bering River field embraces 21.6 square miles underlain by anthracite and 22.7 square miles underlain by semibituminous and semianthracite coal. The coal-bearing rocks trend to the northeast into the unsurveyed high ranges, and it is quite probable that there are considerable areas in the unsurveyed extension of the coal field or possibly other coal fields beyond the one surveyed.

The workable coal beds in this field vary from 6 to 25 feet in thickness, though local swellings occur, giving a much higher maximum. They are included in a great series of sandstones and shale of Tertiary age (Miocene?) which are closely folded and faulted. In quality the coals vary from an anthracite, with 84 per cent of fixed carbon, to a semibituminous, with 74 per cent of fixed carbon (see p. 571). The field includes some coking coal. There is no good harbor at Controller Bay, though plans have been made for building a breakwater. Another scheme of obtaining access to the coal is by constructing a railway from Cordova Bay, a good harbor lying 100 miles to the west. This railway is now (1908) about half completed.

COOK INLET.

Lignite-bearing Tertiary rocks occur widely distributed in the Cook Inlet region. These are usually little disturbed, but locally are considerably folded and faulted. The largest areas of coal-bearing rocks in this field occupy the western part of the Kenai Peninsula and are in pare buried under a cover of Quaternary gravels. It is not impossible that the entire Cook Inlet depression may be underlain by the coal-bearing formations.

The best-known part of this field lies adjacent to Kachemak Bay on the north, where 2,000 to 3,000 feet of coal-bearing rocks are exposed. These contain an aggregate thickness of over 60 feet of workable coal beds, the thickest of which is about 7 feet. Lignite in workable seams has also been found at Port Graham and Tyonek.

Though the Kenai Peninsula was the scene of the earliest (1854) coal-mining venture in Alaska, the output has been only a few thousand tons. These coals, in spite of their accessibility to tide water, can probably not compete with the higher-grade fuels, such as those of the Matanuska field. It seems probable that the coal reserves in the Cook Inlet region are very large, for the area of the coal field is estimated at 2,565 square miles.

MATANUSKA REGION.

The Matanuska coal field shares with that of Bering River the preeminence in the present fuel situation in the Territory. This field lies about 25 miles from tide water at Knik Arm, a northerly embayment of Cook Inlet. As, however, Cook Inlet is frozen during the winter months, the distance to tide water must be measured to the eastern side of Kenai Peninsula, about 150 miles.

The known commercially valuable coals of the Matanuska are included in folded and faulted rocks of Tertiary (Eocene?) age, including shales, sandstones, and conglomerates aggregating 3,000 feet in thickness. The coal-bearing series has been traced for 50 to 60 miles along the Matanuska Valley, but much of it is buried under a heavy blanket of Quaternary gravels. At the western end of the district the bituminous coal, which seems to form the main body of the field, appears to pass into a lignite, while there is some evidence that the same coal is represented by an anthracite at the eastern end of the belt. This anthracite may, however, belong to an older coal-bearing formation.

The commercial coals of the Matanuska field vary from a subbituminous to a semibituminous. There is also some anthracite, but of this less is known. It is evident from the facts in hand that there is a large amount of high-grade bituminous coal in this district. The beds vary from 5 to 30 feet in thickness.

So far as at present known, the total area underlain by commercial seams aggregates 46.5 square miles. As, however, much of the field is covered by gravels and as it has not been surveyed in detail, the coal-bearing area may be much larger. The total area of what may prove to be coal-bearing rocks is approximated at 900 square miles.

A railway is under construction which will lead to the opening of this field. This will bring about the development of the high-grade fuels, of which there is a large quantity. The lignites lying to the west of the Matanuska field will not now bear shipment until the coals of the higher fuel value approach exhaustion. As there is believed to be a very large amount of lignitic coal in this general province, it will be an important element of the ultimate fuel reserves of the Territory.

ALASKA PENINSULA REGION.

The widely distributed coal of the Alaska Peninsula and adjacent islands is in part of Cretaceous and in part of Tertiary (Eocene) age. It is chiefly lignite, but some good bituminous coals occur in this field. The rocks in which the coal beds occur are gently folded and locally, at least, considerably faulted. The total area of the coal fields of this province is estimated at 980 square miles, while that known to be underlain by coal is 61 square miles. About one-half of the coal-bearing area and about one-third of the probable coal field is lignitic, the balance varying from subbituminous to bituminous in quality. Coal has been mined in this field at Chignik and Herendeen bays and on the island of Unga for local use, but the total output has been only a few thousand tons. These coal fields are all readily accessible from good harbors and will form one of the early available fuel assets of the Territory when the demand for coals of this grade warrants their exploitation.

YUKON REGION.

The coals of the Yukon, including bituminous and subbituminous, together with a large amount of lignite, are for the most part of Tertiary (Eocene?) age. Some of the bituminous may, however, be of Upper Cretaceous age. The Tertiary lignitic coal beds typically occur in association with conglomerates, sandstones, and shales, usually only little deformed, but sometimes profoundly folded and faulted. The bituminous coals, which are confined to the lower Yukon, occur with finer sediments, which have been gently folded and somewhat faulted.

The lignitic coal beds occur up to 20 feet in thickness, the bituminous in beds from 2 to 3 feet. These comparatively thin seams have not encouraged exploitation, in spite of the high price of mineral fuel in this central region, but a small production has been made for the use of the Yukon River steamers.

Coal-bearing beds are so widely distributed in the Yukon region that it will not be feasible to give an account of all the occurrences. The three largest fields are (1) Nulato region, (2) Nenana region of the lower Tanana Valley, (3) Washington and Coal Creek belt of the upper Yukon. Of these the Nulato field contains the best coal, while the Nenana is the most extensive and has the thickest beds. The total area known to be underlain by coal in the entire region is 264 square miles, while the coal fields may embrace 2,000 square miles or more.

These Yukon coals will have a high value for local use when the scant supply of accessible timber has been exhausted. There is a constantly increasing demand for power in the placer districts, and this can be met only by developing the water powers, which are not extensive, or by utilizing the coals. The low fuel values and the difficulties of transportation of these coals will probably lead to their local transformation into electric power, to be transmitted to the mining camps. The location of some of the lignite fields with reference to the placer fields is well suited for this purpose.

That a large amount of lignite in excess of any future local demand that can now be foreseen occurs in the Yukon region can not be denied. So far as exportation is concerned, it is certain that the low fuel value of these coals and their inaccessibility will lead to their conservation until the fuel supply of other regions approaches exhaustion.

SEWARD PENINSULA.

The known coal-bearing areas of Seward Peninsula do not exceed a few square miles, and the quality of the coal is of a low grade. This coal, however, is worthy of mention, because it can probably be locally utilized to furnish power for mining purposes, and hence conserve the higher-grade coals which are now being brought in from outside sources. This appears to be a good example of the way a local supply of lignite may reduce the consumption of higher grade fuels. Its success will depend on the development of economical means of utilization of these low-grade fuels, so as to bring them within the sphere of commercial practice and permit their substitution for higher-grade fuels transported from a distance.

NORTHERN ALASKA.

Geographically, the known coal fields of northern Alaska fall into three groups: (1) Cape Lisburne, (2) the Colville Valley, (3) Wainwright Inlet. Coal has also been reported to occur between these areas, as well as east of the Colville River. The Cape Lisburne field includes the Corwin and Cape Beaufort districts.

Three coal-bearing formations are recognized in this northern field: (1) lower Carboniferous (Lisburne formation), made up of slates, shales, and limestones, with some high-grade bituminous coals, and having a thickness of 500+ feet; (2) Jurassic (Corwin formation), including at least 15,000 feet of shales, sandstones, and conglomerates and containing a large number of subbituminous coal beds; (3) Tertiary (Kenai formation?), made up of conglomerates, sandstones, and shales, with lignitic coal seams. The two lower formations are considerably folded, but the Tertiary beds are, as a rule, only little disturbed.

The total area known to be underlain by coal aggregates 302 square miles, while the coal fields, roughly outlined from the data in hand, include some 3,000 square miles. The scant evidence at hand points to the conclusion that a survey of this northern region will show very large coal fields in this part of Alaska.

A little mining of coal for local use has been done in the bituminous field near Cape Lisburne and in the lignitic field of Wainwright Inlet, but the region as a whole is practically untouched. It is certain that there will be no extensive mining in this northern field for a generation or two to come. These coals are too inaccessible to invite exploration, either under the present demands or any that can now be foreseen.

THE COAL RESERVES.

INTRODUCTION.

It will be evident from the facts presented that there are few data on which even an approximate idea of the available tonnage of Alaskan coal can be based. Of the 1,238 square miles believed to be underlain by coal, less than one-quarter has been surveyed in sufficient detail to yield any quantitative data whatever. Even where such surveys have been made, a large factor of uncertainty is introduced either by the folded and faulted condition of the coal beds, which exists in some fields, or by the lack of definite knowledge of the continuity of the coal beds in others. There must, therefore, be a very large element of uncertainty in the tonnage estimates of the 300 to 400 square miles of surveyed coal fields. Moreover, in Alaska there are practically no available data from private sources, such as the results of extensive mining or prospecting operations, which have formed an important element in the estimates made of the mineral resources in the States.

The estimates of tonnage to follow were made on the following basis:

1. No beds less than 3 feet thick were assumed to be workable or contributed to the tonnage.

2. The depth of workability was assumed to be 3,000 feet in the case of the highest-grade coal (anthracite, semianthracite, semibituminous), 2,000 feet in case of the better bituminous and subbituminous coals, such as those on the lower Yukon and at Cape Lisburne and on the Matanuska River, and 1,000 feet in the case of the poorer subbituminous and all the lignites.

3. The tonnage was computed by the following formula: Tonnage = area of bed to limit of workability (square miles) × thickness (inches) × sp. gr. × 72,600.

4. The specific gravity was assumed to be 1.30 for lignite, 1.35 for bituminous, and 1.38 for the high-grade coals.

5. Bering River field: A certain percentage of the coal-bearing rocks is shown by the average sections to consist of workable coal beds. This percentage of the computed bulk of rock to limit of workability gave the estimated tonnage.

6. Nenana coal field: As for Bering River, with the necessary change for percentage of coal in rocks.

7. Matanuska coal field: Each bed was estimated separately according to its average thickness, length, according to a safe assumption of continuity, and width on the dip to the limit of workable depth.

8. Lisburne fields: The Corwin district was computed like the Matanuska, length of beds being assumed to be the distance from the shore to the edge of the area colored on Collier's map. The Beaufort district was assumed to have one-half the tonnage per square mile of the Corwin district.

9. Yukon field: Each bed figured as in Matanuska, but the beds were not assumed to extend in any case more than 1 mile in each direction from the mine or prospect where they had been exposed, except in the Washington-Bonanza district, where a continuity of 50 miles on the strike was assumed.

10. Cook Inlet field: Computed as for the Matanuska.

All the other fields were estimated on the basis of a most conservative estimate of thickness of coal underlying the field and an area believed to be a safe minimum. Neither in this case nor in any of the others was the coal assumed to go beyond where we have reliable information from members of the Survey concerning it. The areas used in making the last class of estimates are consequently very small and are subject to a possible immense extension in the light of subsequent work.

Estimate of tonnage and areas, Alaska coal fields.

	Tonnage.	Areas believed to be underlain by coal.	Supposed areas of coal fields.
	Short tons.	*Sq. miles.*	*Sq. miles.*
Anthracite, Pacific coast	1,611,700,000	25.8	....
Semianthracite, Pacific coast	517,100,000	7.2	....
Semibituminous:			
Pacific coast	1,425,800,000	35.8	....
Arctic slope	66,800,000	14.2	....
Total semibituminous	1,492,600,000	50.0	....
Total high-grade	3,621,400,000	83.0	620
Bituminous:			
Pacific coast	2,600,000	2.0	900
Interior region	15,900,000	162.0	2,475
Total bituminous	18,500,000	164.0	3,375
Subbituminous:			
Paific coast	535,500,000	49.7	657
Interior region	59,200,000	6.0	15
Arctic slope	3,465,600,000	205.0	1,323
Total subbituminous	4,060,300,000	260.7	1,995
Lignite:			
Pacific coast	2,173,100,000	237.0	2,938
Interior region	4,228,000,000	264.5	2,003
Arctic slope	1,003,200,000	93.0	1,736
Total lignite	7,404,300,000	594.5	6,677
Summary by provinces:			
Pacific coast	6,265,800,000	357.5	5,115
Interior region	4,303,100,000	432.5	4,493
Arctic slope	4,535,600,000	312.2	3,059
Grand total	15,104,500,000	1,102.2	12,667

The incompleteness of these figures can best be illustrated by some examples. The Bering River field may be extended into the mountains and have many times its present known area. If the entire eastern and western extensions of the Matanuska Valley are underlain by coal beds, as may be the case, it will increase the tonnage of this field many times that used in the present estimate. In the Cook Inlet and Susitna regions the estimates for tonnage are based on a coal field of 30 to 40 square miles. As a matter of fact, it is not improbable that the whole Cook Inlet-Susitna depression may be underlain by coal-bearing rocks at no depth prohibitive of mining. If this is the case, this coal field might embrace 10,000 to 20,000 square miles.

In view of these facts, it is perhaps conservative to multiply the above figures by 10 or even by 100 to arrive at an approximation of the fuel reserves of this vast unexplored region. This is especially true of the lignite reserves, for there are known to be very extensive fields of low-grade coals in Alaska.

PRODUCTION AND CONSUMPTION.

Though an attempt at mining coal on Cook Inlet in 1854 by the Russians was the first mining undertaken in the Territory, yet the total output up to the present time has been very small, as indicated in the following table. In 1907 there were four productive coal mines in Alaska.

Production of coal in Alaska, 1888–1907.

Year.	Short tons.	Value.	Year.	Short tons.	Value.
1888–1896 [a]	6,000	$84,000	1903	1,447	$9,72
1897	2,000	28,000	1904	1,094	7,22
1898	1,000	14,000	1905	3,774	13,20
1899	1,200	16,800	1906	5,541	17,97
1900	1,200	16,800	1907	10,139	53,60
1901	1,300	15,600			
1902	2,212	19,048	Total	37,507	296,0

[a] The production for 1888–1896 is estimated on the best data obtainable. That for the years subsequent to 1896 is based for the most part on data supplied by operators.

The smallness of the output is chiefly due to two reasons: First, because up to a decade ago, when the rapid advancement of the gold-mining industry began, the local demand for coal was very small, being confined to that of the canneries and shipping interests and the Treadwell mine, which could be supplied at low cost by the fuels brought from Vancouver Island or Washington. Second, the existence of extensive bodies of high-grade coal in Alaska, geographically situated so that it could be exported, has been generally known only for a few years. Since the discovery and surveys of the Controller Bay and Matanuska regions there has been much activity looking to the development of these two fields. As, however, the marketing of this coal requires the construction of 150 miles of railway in one field and 100 miles of railway or 25 miles of railway and possibly an expensive breakwater in the other, the progress of exploitation is necessarily slow. Moreover, the uncertainty of obtaining title to coal lands, which still exists, has made capitalists rather guarded in furnishing the money necessary for these enterprises.

Though the Territory has produced annually only a few thousand tons, the consumption of coal during the past decade has rapidly increased. The following table presents the available statistics regarding consumption of mineral fuels in Alaska:

Shipments of coal and coke to Alaska, July 1, 1903, to June 30, 1907.[a]

	Twelve months ending June 30—							
	1904.		1905.		1906.		1907.	
	Quantity.	Value.[b]	Quantity.	Value.[b]	Quantity.	Value.[b]	Quantity.	Value.[b]
	Long tons.		*Long tons.*		*Long tons.*		*Long tons.*	
Domestic anthracite			5	$885			476	$7,090
Domestic bituminous	41,704	$193,740	42,245	187,352	67,293	$265,047	48,383	270,651
Domestic coke	392	2,251	478	4,281	346	3,676	3,108	25,629
Foreign anthracite			10	148	304	1,836	25	216
Canadian bituminous	63,652	261,967	59,272	260,110	41,481	187,312	64,029	287,948
Australian bituminous	1,609	4,303					3,529	8,587
Japanese bituminous							11,546	33,789
Foreign bituminous, shipped via United States	3,324	23,904	5,550	29,673	706	4,838	4,141	28,679
Foreign coke					7,628	38,139	2,959	14,795
Total	110,681	486,165	107,580	481,657	117,758	500,848	138,196	677,384

[a] Commerce of the noncontiguous territory of the United States, Bureau of Statistics, 1904, 1905, 1906, 1907.

[b] At port of shipment.

Shipments of petroleum to Alaska.[a]

Period.	Crude petroleum.			Naphthas.	
	Gallons.	Barrels.	Value.	Gallons.	Value.
Six months ending—					
December, 1902	21,000	500	$290	60,358	$12,186
June, 1903	840,000	20,000	28,000	210,147	33,831
December, 1903	1,008,000	24,000	36,000	84,776	18,054
June, 1904	1,008,400	24,010	35,823	231,658	43,814
December, 1904	1,008,030	24,001	33,603	106,623	23,904
June, 1905	1,780,325	42,389	59,204	490,196	75,187
December, 1905	935,060	22,263	31,864	214,300	34,734
June, 1906	1,428,000	34,002	20,400	361,681	60,214
December, 1906	1,260,100	30,000	18,009	219,297	40,480
June, 1907	2,545,200	60,000	36,360	254,210	59,012
December, 1907	6,558,500	156,155	107,146	282,671	60,333
June, 1908	3,852,940	91,736	55,482	599,959	91,064

[a] Monthly Summary of Commerce and Finance, Bureau of Statistics, 1902–1906.

SUMMARY AND CONCLUSIONS.

The advancement of copper and gold mining, construction of railways, etc., will cause a constantly increasing consumption of coal. It would appear to be in accord with a policy of conservation of mineral fuels to meet this demand from the local supply. Every ton of coal or barrel of petroleum shipped to Alaska by steamer or rail entails a certain amount of fuel consumption for transportation. Moreover, this long carriage is commercially possible only for high-grade fuels, while for local consumption the large supply of lignites of lesser fuel value can be utilized. For example, many of the Alaskan river steamers, now using California petroleum as fuel, could be supplied by the local lignites. This would prevent a double waste: (1) The more valuable fuel is consumed instead of the more abundant lignite, and (2) as the petroleum is brought nearly 4,000 miles by steamer, fuel is used for its transportation. The utilizing of the coals in the Yukon region as a substitute for wood would also conserve the scant supply of timber.

Again, the use of the local coking coals for the reduction of the copper ores will effect a saving of mineral fuels. At present the copper ore is shipped a distance of 500 to 1,500 miles, while if it were smelted near its locality of production 70 to 90 per cent of the material could be left behind, with a corresponding saving of fuel used in transportation. Another saving would be brought about in the case of Alaska steamers now carrying coal from the southern ports for the round trip, if the local fuels were utilized for the return journey.

Discussion of the future utilization and conservation of Alaska's coal supply can best be made by considering separately the same three geographic provinces under which the coal fields have been described: (1) The Pacific slope, (2) the central regions, (3) the northern region. These will here be considered in the reverse order in which they have been given.

The northern coal fields lie in a region tributary to the Arctic Ocean, which is locked in the ice for all but two or three months in the year. Some lie close to the seaboard; others far inland. While little is known of the fuels of this region, all the facts available point to the conclusion that this province contains very extensive coal fields. These mineral fuels are in a region where there are practically no industries and with little promise that any will be developed and the coals are unavailable until the more accessible mineral fuel supply of the world approaches exhaustion. To bring them to a harbor open throughout the year would mean the construction of at least 1,000 miles of railway. Such a haulage, leaving out all other considerations, is of course prohibitive for any present fuel demand. Moreover, these coals are not needed, nor likely ever to be, for any local use, except some of those at Cape Lisburne, which may be utilized for local shipping, and some others which may be used by the scant Eskimo population, now that the supply of driftwood is approaching exhaustion.

The fuels of this northern region can, therefore, be regarded as conserved by the geographic conditions until future generations may have to draw upon them. They can consequently, for the most part, without injury to any existing commercial interests and without retarding the development of the country, be placed under such legislative provisions as will permit their utilization only under such restrictions as the future conditions of the mining industry shall demand.

The coals of the central region are in part accessible to rivers navigable during the summer months and in part lie near the proposed railways from the Pacific to the Yukon. There also remains a considerable percentage but little more available to the present generation than the fuels of the northern fields. These coals are chiefly lignitic in character and, under no demand which can now be foreseen, could be utilized for export to other districts. To bring them to the States would require a railway haulage of 400 to 500 miles and then transportation by steamer for 1,000 to 1,500 miles in addition.

On the other hand, the development of these fields to supply the local demand will conserve (1) higher-grade fuels now imported from great distances and (2) local supply of timber. While little is known of the amount of coal available in this central province, there is every reason to believe that it is far beyond any local demand of the future.

The conservation of the coal of the Pacific slope province is a more complex problem, both because of the high grade of some of the fuels and of their greater accessibility. While none has yet been exported, the great demand for the high-grade bituminous and anthracite coals, such as are found in the Controller Bay and Matanuska regions along the Pacific coast, will lead to their exportation as soon as railways make them accessible. It is probable that the market for these coals will for a long time exceed the production, which will greatly stimulate mining activity once the transportation problem has been solved. When the coals are put on the market, they will probably curtail, if not entirely cut off, the demand for the lignitic and lower-grade bituminous coals which are so abundant in the Pacific coast province of Alaska. Therefore the production of the high-grade fuels will effectually conserve those of lesser fuel value for the present. Some of these low-grade fuels, however, are so accessible and so abundant that future demands and strong competition may lead to wasteful methods of mining, provided they are all permitted to pass into unrestricted private ownership.

The reserve of these anthracite and bituminous coals of the Pacific slope, while it can not now even be approximated, in all probability is far below that of the lignites. It seems probable that an extensive area of the high-grade fuels may be found among the high mountains and glaciers to the northeast of the present known limits of the Bering River field. If such be the case, this will be another locality where the geographic conditions will prevent mining until there is far more demand for the fuel than at present. In the Matanuska there is probably also a large quantity of coal under the Quaternary coating of gravel. Making allowances for future discoveries, however, the high-grade fuel is not abundant, considering the demand for it.

From the standpoint of conservation and economic utilization, the possibility of intense competition between the coal of the Bering and Matanuska fields and that of Puget Sound is the danger point in the prospective situation. If each field develops only to the extent of supplying the demand for the kind of coal which it best can furnish, then the immediate use of the coal will be legitimate and economical. But if the individual fields develop beyond the demand of their respective proper markets—if the Bering River field produces more than the needed supply for steamship, smithing, and local railway and smelting needs and of domestic anthracite, if the Matanuska produces more than is needed for its local railways and smelters, for bunker coal at its tidal terminus, and for shipment to the Pacific coast coke ovens, and if the coal from other fields invade these markets—there is sure to be ruinous competition, which may lead to cutting prices with the sole object of destroying all competition and establishing a general monopoly. In such ruinous competition as has existed in some of the eastern fields the coal fields will be robbed of the more cheaply minable coal at the cost of the destruction of larger amounts which will be left in the ground so crushed and buried that it can never be recovered, coke for distant shipment will be made by wasteful processes at the mines instead of shipping the coal to points where both the coke and the by-products can be used, coal will be coked which would better be used for other purposes, and the waste by consumption en route will be extended to the Alaska coals.

If these high-grade fuels, some of which make excellent coke, are not exploited, several conditions will probably be brought about:

First. The west coast of the United States will probably continue to draw heavily on the fuels of British Columbia, Australia, and Japan, and to the amount imported will conserve its own supply.

Second. There will be an increasing demand for fuel oils, which, while it may not affect the production, will stimulate the search for new oil fields.

Third. The west coast will probably continue to rely on the East for its pig iron and steel, for in the absence of good cheap coke—except as Alaska can supply it or the processes of coking coals are improved—the local supplies of iron ore will not be utilized, unless, possibly, by electrical methods of smelting. As a concomitant to this, the iron ore and coking coals of the East, which are of the most value to the nation, being nearest the centers of the population, will be correspondingly diminished.

Fourth. What has been said of the relation these coals bear to the development of an iron industry on the Pacific coast is to a lesser extent true of copper smelting. Without the use of Alaska coke either the copper ores will be transported to British Columbia or Puget Sound or the coke will be brought to the copper deposits. In either case there is a loss in transportation. While it is true that these factors will affect the copper-mining industry and lead to the exploitation of only the richer deposits, yet the past few years have shown that it is economically possible to bring either the coke to the copper or the copper to the coke.

Fifth. Certain loss of fuel in transporting eastern coals to the west coast for certain purposes where their use is imperative will continue. This is, however, a small item, as the total tonnage of eastern coals to the West is insignificant.

Sixth. There will be no local supply of high-grade coals on the west coast for the use of the navy.

In considering the above facts it must be remembered that these Alaska bituminous and anthracite coal fields can be made accessible only by the expenditure of a very large amount of money. The millions of dollars necessary for the development of these fields will not be forthcoming unless provision be made by which a large tonnage of coal will be made available.

PEAT.

Peat is found in nearly every part of Alaska except in the high ranges. The humidity of the Pacific coastal zone and the consequent luxuriant vegetation favors the accumulation of peat. Southeastern Alaska is heavily forested and often has dense growth of underbrush with a flooring of moss. In southwestern Alaska timber is entirely absent, but all the lowland and much of the upland regions are covered with moss, grass, and small shrubbery. The prevailing humidity in both these districts favors the accumulation of vegetable refuse. Though there has been no prospecting for peat in this part of the Territory, deposits are known at least 15 to 20 feet in thickness and are believed to be of good quality.

Central and northern Alaska have a much smaller precipitation. Here, however, the soil is nearly everywhere mantled by a dense blanket of moss and other vegetation. This is especially striking in the extensive timberless areas or tundras which lie along Bering Sea and the Arctic Ocean. In these two provinces the subsoil is usually frozen, which retains the waters at the surface. The moss, except in excessively dry weather, is usually saturated with water. All these conditions, which promote vegetable growth and retard evaporation and oxidation, are favorable to the formation of peat. As a matter of fact, there is nearly everywhere a layer of peaty material underneath the soil. In some natural exposures peat deposits have been observed in these provinces having a depth of 30 to 40 feet. While the widespread surface layer of peat is of an inferior quality, some of the deeper-lying beds are probably of high grade. There are no data whatever at hand to estimate the available supply of peat. As, however, it is found in every part of the Territory and on the great tundras of the north, occupying at least a quarter of the Territory and comprising layers of greater or less thickness, the supply must be enormous and possibly exceeds that of the entire United States.

In the presence of more easily available fuel there has been no occasion to utilize any of the peat beds, so practically nothing is known of their fuel value, extent, or thickness, except what has been stated. Probably the only place in Alaska where this mineral fuel has been exploited is a peat bed saturated with petroleum residue, near Cold Bay, on the Alaska Peninsula, where the material has been used for fuel at the neighboring oil drills. Here, however, it is the petroleum residue rather than the peat which gives the deposit its chief value.

The peat deposits have at present no value, since lignitic and better-grade coals are too widely distributed to encourage the use of a less available fuel. The time appears also very remote when these peat deposits (except at localities where coal is absent) will be utilized. Certainly recourse to the peat will take place only when the more valuable mineral fuels are not obtainable.

PETROLEUM.

[By G. C. Martin.]

Petroleum may exist in the rocks at many places in Alaska, but at only four localities are the known indications sufficient to justify drilling. Wells have been drilled at three of these localities, but petroleum has been obtained in quantity at only one of them. In all of these the petroleum is of the high-grade variety, suitable for refining, like that from Pennsylvania. These four will be briefly described.

The Katalla field is situated near the mouth of Copper River, in latitude 60° north, longitude 144° west, or about 1,250 miles northwest of Seattle and 400 miles northwest of Sitka. The rocks in this field consist of Tertiary shale, sandstone, and conglomerate. The structure is complex, the rocks being steeply and intricately folded and cut by faults. These conditions would raise doubt concerning the existence of bodies of oil if it were not for the abundant seepages and the presence of oil in the wells. As it is, they increase the cost and other difficulties of drilling and make it entirely impossible to estimate the area of the probable oil-producing territory.

Sixteen wells have been drilled in the Katalla field. The result has been a moderate production of oil from one well and the demonstration of smaller quantities in three others. As only a small part of the area in which the presence of seepages suggests an oil field has been drilled, the proof of the existence of any considerable volume of oil is yet to be made.

The Cook Inlet oil fields are about 320 miles west of Controller Bay on the middle part of the west shore of Cook Inlet. Seepages are here numerous and prolific, but though several wells have been drilled, none has yet proved successful. This field is in an area of Jurassic rocks which are chiefly shales and sandstones. The folding is much more moderate than at Controller Bay, but many faults are present. The relation of the occurrence of oil to the geologic conditions has not been discovered, and hence the areas of possible oil-producing territory are entirely problematical.

At Cold Bay, on the Alaska Peninsula, 160 miles southwest of the Cook Inlet fields, there are many large seepages and several wells have been drilled, none of which has produced more than traces of oil. Here, as in the Cook Inlet field, the rocks are chiefly Jurassic shales and sandstones. The structural conditions are not unlike those on Cook Inlet.

Near Cape Yakataga, 75 miles east of Controller Bay, many large seepages are reported, but owing to the unaccessibility of the region no drilling has been attempted. These seepages are located on Miocene shale and sandstone which are steeply folded.

Summarizing, it may be said that the occurrence of oil is suggested under considerable areas in Alaska, but the presence of profitable oil pools has yet to be shown. The low price of oil on the Pacific coast and the high cost of drilling in Alaska make any attempt to develop the possible Alaska fields at present an unattractive proposition.

All considerations point to the desirability of conserving the Alaska fields until the decline of the California and Mid-Continent fields. When Alaska oil is utilized it should be for refining, and the burning of crude Alaska oil should be discouraged.

IRON ORES.

There being now practically no demand for iron ores on the west coast, such ores have not been sought for in Alaska. The only iron which has been found is that discovered incidentally in prospecting for other minerals, and thus far this has been chiefly magnetite, occurring at only a few localities along the Pacific seaboard. The following note on these deposits has been prepared by C. W. Wright:

> Magnetite is the only iron ore that has been found in southeastern Alaska in commercial quantities. This ore occurs in large bodies, forming contact deposits along the contacts of diorite and limestone on Prince of Wales Island,

where it is associated with the copper deposits, and occurring as magmatic segregations associated with basic intrusive rocks at several points along the mainland coast.

At the copper mines of Prince of Wales Island a considerable tonnage of magnetite carrying from one-half to 1½ per cent of copper has been developed which can not be profitably mined as a copper ore. However, if there were a market for the iron in these ores, the copper could be readily separated mechanically and the deposits mined with profit. The surface showings of magnetite in this copper district are very large, and the estimated tonnage, with a depth of only 30 feet, is about 3,000,000 tons of magnetite. There is, of course, a much greater amount of possible ore, concerning the extent of which almost nothing is known. These ores for the most part contain practically no phosphorus or detrimental impurities, and may be classed as Bessemer ore.

Explorations have been begun to develop magnetite deposits near Haines, on the mainland coast of Lynn Canal, but little is known as yet of their extent or the character of the ores.

U. S. Grant, in his study of the copper deposits of Prince William Sound, noted some hematite ores, but could not determine whether the ore was present in commercially valuable deposits. He also reports the occurrence of magnetite associated with pyrrhotite on Prince William Sound and with chalcopyrite near Seward, on the Kenai Peninsula. His investigations, on the whole, do not encourage the idea of the presence of workable iron ores in this district.

In the Iliamna Lake region there are some copper deposits which from accounts, appear to be of similar origin to those of Prince of Wales Island. With these is said to be associated a large amount of magnetite. So far as known, iron-ore bodies have been found at only one place in the interior. At this locality, which is near the head of the Nabesna River, there is a 2½-foot vein of magnetite which occurs in a limestone near the contact with an intrusive.

The conditions of occurrence of both types of southeastern Alaska magnetite deposits probably repeat themselves along other parts of the Pacific coast line, so that there is a probability that similar bodies of iron ore occur elsewhere. Though the evidence is very scant, it is not impossible that Alaska may have important iron-ore reserves.

GOLD.

INTRODUCTION.

Mr. Lindgren's general report on precious-metal resources of the United States, contained in this volume, emphasizes the fact that no definite statement of the gold reserves is possible. If this be true of the United States, it is far more so of a little-known region like Alaska, where the auriferous deposits have been found in widely distributed districts, usually separated by extensive areas, often but little prospected, sometimes almost unexplored. Moreover, except in southeastern Alaska, the auriferous deposits thus far developed are primarily those of the alluvium, and there has been little search for lodes. Therefore, in most of the gold-placer districts the possibilities of developing an auriferous lode-mining industry are almost unknown.

Geologic survey and investigation, when executed with sufficient thoroughness, lead to definite results concerning the distribution and occurrence of auriferous deposits. If a region has been mapped in detail, the geologist can outline with a fair degree of certainty those areas worth prospecting for gold. Such investigations, however, can be interpreted quantitatively only to a very limited degree in reference to placers and are practically worthless for the purpose of forecasting the gold content and reserves of undeveloped lode deposits.

The actual valuation of developed lode deposits can, of course, be carried only to the limits of the mine workings, which permit the blocking out and sampling of the ore bodies. Such an investigation can be made only at great cost and is properly the function of the mine owner and not the federal geologist.

Placer deposits, whose values are far more regular of distribution, admit of a rough valuation by the geologist; but even in the case of placers the quantitative determination of gold contents in any given body of gravel can be arrived at accurately only by extensive excavations are drilling, and by sampling. This also is evidently the function of the mine owner and not of the federal geologist. Most Alaska placer miners have done so little careful prospecting of their properties as to make their statements in regard to metal contents of but little service in estimating the placer gold reserves. Such data as are available have been carefully compiled by the Geological Survey, but while they may have value in forecasting the direction of future mining development, they are far too inexact and incomplete to admit of more than a bold guess at the gold reserves. Any estimate made at the present time can not take into account the latent possibilities of the hundreds of creeks which, though unprospected, are believed to lie within the gold-bearing area.

In the following account emphasis will be laid on the subject of general distribution and occurrence of the auriferous deposits, because it is believed that such data form the most important element in the valuation of these deposits. Given this information, together with a statement of past production, the technician at least is able to draw his own conclusions.

GEOLOGIC AND GEOGRAPHIC DISTRIBUTION.

The known gold deposits of Alaska can be grouped into three general types: (1) Gold occurs near the contacts between granitic or other igneous intrusions and altered sediments. (2) It occurs in metamorphic schists. (3) It occurs in association with Mesozoic or Tertiary volcanics. Nearly all of the auriferous lodes which have thus far been productive are of the first type, while the second appears to be typical of most of the important placer districts. Examples of the third type have been so far limited to only a few localities. There is some evidence to indicate that the source of the gold of the placers occurring in areas of schistose rocks may be in veins which bear a genetic relation to, as well as a close association with, igneous intrusives. If this proves to be generally the case, it may be found that the deposits assigned to the first two groups may be practically identical in origin.

Most of the auriferous deposits occur in rocks which have been more or less highly altered, but the metamorphism in the placer districts has usually been more pronounced than in lode districts. There are no considerable areas of metamorphic rocks known in Alaska which are not locally more or less auriferous, so that the distribution of these rocks is one of vital importance to this discussion. The metamorphic terranes vary in age from Cambrian or pre-Cambrian to Carboniferous and possibly Triassic. There are also some altered Cretaceous beds which are locally auriferous. While in Alaska their geologic age has little direct bearing on the question of the distribution of gold, yet the most important gold fields now developed are in regions where the rocks belong chiefly to lower Paleozoic or older terranes.

Three considerable belts of metamorphic rocks traverse the Territory. One of these skirts the Pacific seaboard, embracing the auriferous lode and placer districts of southeastern Alaska (see map, Pl. I), the Prince William Sound copper district, and some small gold-bearing areas lying in between. Its southwestward extension is found in the Kenai Peninsula and on Kodiak Island, where it includes some placer and lode deposits.

A second belt stretches southwest from the international boundary, near the famous Klondike district, and includes the Fortymile, Birch Creek, Fairbanks, and other gold placer-bearing areas. Its extension is probably to be sought in the little-explored region lying between the lower Yukon and the Kuskokwim, and may include the newly discovered placers of the Innoko Valley.

The third belt lies north of the main Yukon Valley, includes the gold placers of the Chandalar, Koyukuk, and Kobuk districts, and may find its continuation in the auriferous metamorphic rocks of Seward Peninsula.

In addition to these broad belts thus defined, there are some smaller areas in which gold has been found, such as those of the Nizina, of the Chistochina, of the Yentna, of the Bonnifield, and of the Kantishna districts. These, with others, which will not be enumerated, have yielded some placer gold.

SOUTHERN ALASKA.

The auriferous deposits of southeastern Alaska have been investigated by C. W. and F. E. Wright and A. C. Spencer, from whose reports the following data are drawn: This province is the one in which the close association of the metalliferous lodes with the intrusives is most strongly marked, and where this relation was first worked out. It appears that the strongest mineralization lies close to the western margin of the great intrusive masses of the Coast Range. Similar intrusives are, however, widely distributed in isolated stocks throughout the coastal region of this part of the Territory and its adjacent islands, and these, too, have been found to be mineralized at a number of localities. As there are hundreds of miles of these contacts, and as but few of them have been carefully prospected, the chances of finding additional auriferous lodes appear to be good. At the same time it should be noted that the mere fact of mineralization does not imply the existence of valuable deposits, and that, in spite of the fact that this part of Alaska has been the scene of active mining for nearly thirty years, only the Juneau district has furnished any considerable gold output, and this has chiefly come from the three mines of the Treadwell group. In the Ketchikan district, embracing the southern part of southeastern Alaska, there has been some exploitation of auriferous lodes. Though some of these have carried high values, they are all comparatively small, and many have proved not very persistent.

The value of the total gold output of southeastern Alaska from 1880, when mining first began, to the close of 1907, was nearly $40,000,000, which has come chiefly from the lodes. Its future as a gold producer is promising, yet, excepting the few developed mines, there is but a small tonnage of ore in sight. With the densely forested conditions that prevail, the search for ore bodies has been much impeded, and in spite of its accessibility the region can not be said to have been carefully prospected. There is therefore little on which to base predictions of future production, except the geologic conditions which are favorable to the discovery of new ore bodies. The deepest workings (1,600 feet in the Treadwell mine) indicate a persistence of gold content in deposits of this type which is encouraging.

ST. ELIAS RANGE.

Auriferous sands whose materials have been derived from the metamorphic rocks of the St. Elias Range have been found and mined in a small way at a number of localities. These and what is known of the rocks of this range suggest that here may be a locus of future gold mining, but the facts at hand do not permit a definite statement.

KENAI PENINSULA AND KODIAK ISLAND.

Auriferous gravels have long been known to occur on the Kenai Peninsula. In fact, it was here that the Russian mining engineer Doroshin found the first placer gold (1884) known in Alaska. The placers of the northern part of the Kenai Peninsula have been productive since 1895, with an aggregate output valued at about $2,000,000. For several years, however, the production has fallen off, and it appears that the richest of the known gravels have been exhausted, though there are extensive bodies of alluvium carrying low values. The gold has been derived from metamorphic rocks, and intrusives appear to be absent. The same geologic conditions appear to prevail throughout the eastern part of the peninsula, and other discoveries may be made. Both in the Kenai Peninsula and on Kodiak Island, which lie in the same general geologic province, some auriferous lodes have been found. The accessibility of this region would permit the mining of low-grade ores, so that there is a possibility of a gold production from this district even after the placers have become exhausted.

SUSITNA BASIN AND ALASKA RANGE.

Auriferous gravels are widely distributed in the Susitna basin and have been found on both flanks of the Alaska Range. It is only within a few years that workable placers have been found, and the entire production does not exceed a few hundred thousand dollars in value. The geologic conditions in the Alaska Range are in some respects very similar to those of southeastern Alaska and are therefore favorable for the occurrence of auriferous deposits. In view of the unexplored condition of much of this field, it is useless to attempt any forecast of its future from the mining standpoint.

COPPER RIVER BASIN.

There are two widely separated auriferous areas in the Copper River basin. The northern area lies on the south flank of the Alaska Range, and the southern area is a western extension of the St. Elias Mountains. What has been said of the future of mining in these ranges applies to these districts excepting that there has been some gold output from these, and they will undoubtedly continue to produce, as systematic mining has hardly commenced.

ALASKA PENINSULA AND ADJACENT ISLANDS.

The Alaska Peninsula region furnishes the only developed example of the third type of auriferous deposits, namely, an occurrence in volcanic rocks. This is at the Apollo mine, which has made a considerable production. Recent information leads to the opinion that there are other similar types of deposit in this general region. If such prove to be the case, this district may also swell the gold production, though at present its entire annual output is confined to a few thousand dollars taken from beach placers and a small production from lode deposits.

YUKON BASIN.

Mining was begun in the Alaska Yukon about 1887, when the Fortymile placers were discovered, but the total production up to the time of the discovery of the Fairbanks placers in 1901 was less than $6,000,000 in value, whereas the production for 1901 to 1907, inclusive, is valued at nearly $30,000,000.

The best known and probably most valuable of the placers of the Yukon basin lie in the so-called "Yukon-Tanana region," embracing an area of some 40,000 square miles between the two rivers, of which about half falls in what may be designated as the "auriferous zone." Within this province lie the Fortymile, Birch Creek, Fairbanks, Rampart, and Hot Springs districts, as well as some smaller ones, all of which have produced placer gold.

This province is the best example of gold occurring in metamorphic schists, but some of its auriferous deposits appear to be intimately associated with intrusive rocks. So far as known, the geologic conditions which prevail in the developed placer districts persist over much of this field. Certain it is that auriferous mineralization is widely distributed, for fine particles of gold occur nearly everywhere in the alluvium. Much of the Yukon-Tanana region is so inaccessible as not to attract the large operator. While the bonanza hunter has hurriedly traversed most of this region, the scarcity of bed-rock exposures and other conditions adverse to prospecting prevent such hasty investigations from yielding definite results as to the presence of gold deposits. Even in the best-known and most accessible parts of the region new discoveries of placers are constantly being made. All these facts indicate that this may be one of the largest placer-gold reserves of the Territory.

The data bearing on the gold contents of the gravels known to carry values have been carefully assembled by L. M. Prindle and F. J. Katz, and these indicate a reserve of about $100,000,000 in value for the ground which has been more or less prospected. This is certainly a conservative estimate, for it takes into account only the auriferous gravels which can probably be mined under the present conditions, or those that will prevail during the next few years, and does not make any allowance for the large unprospected areas.

A belt of schists lying north of the Yukon, extending from Chandalar Valley into the Koyukuk Valley, has been found to be auriferous. Mining has been going on in the latter district since 1899, with a production of probably over a million dollars in value. This field is one of very high cost in mining, and there are probably more extensive deposits with a smaller gold tenor than those now exploited. The Chandalar district has made but a small production, mining having been begun in 1906.

Placer gold has been found at several places in the lower Yukon basin, notably on the Melozikakat, on Ruby Creek, and on the Innoko. Too little is known of the character or extent of these deposits to permit any statement as to their future importance. They prove, however, a wide distribution of the auriferous deposits and indicate possibilities in the way of future discoveries.

Nowhere in the Yukon basin has there been any lode mining, and systematic prospecting for auriferous veins has hardly been inaugurated. As a rule, the mineralization in the schists appears to be disseminated rather than concentrated, but there are exceptions to this rule. Some lode deposits have been found which, in a more accessible region, could probably be profitably exploited. The subject of the future of lode mining in this field does not admit of solution from the data in hand.

SEWARD PENINSULA.

Placer mining was begun on Seward Peninsula in 1897, but it was not until 1899 that the annual gold production exceeded $100,000 in value. The total output of gold up to the close of 1907 was over $44,000,000 in value. Practically all of this gold was taken from the placers, for only one small lode mine has made any considerable production, though a few tons of ore have been taken from several others.

The auriferous deposits of the peninsula can be roughly outlined as occurring in two general belts. One, about 40 miles wide, stretches a little north of east and skirts the southern shore line of the peninsula, embracing the gold placers of Nome, Solomon, and Council. This belt has been traced about 120 miles. The second belt stretches from the neighborhood of Port Clarence to Kotzebue Sound, a distance of about 140 miles, with a width of about 40 miles. In this belt are included the auriferous gravels of Teller, Kougarok, Inmachuk, and Kiwalik. As outlined, these belts embrace an area of about 10,000 square miles. In addition to these areas, evidence of mineralization has been found in the extreme western part of the peninsula, which includes the cassiterite, galena, and other ores of the York region.

In describing the geographic distribution of the mineral deposits of the peninsula, it is not intended to imply that there is any great regularity in their occurrence. As a matter of fact, the distribution of the valuable minerals within these zones is very irregular. The placer gold seems to have been derived, for the most part, from contact zones between massive limestones and various types of schists. P. S. Smith's recent investigations show that other forms of auriferous deposits are those found in black siliceous slates and those in chloritic schists. Other types of mineral occurrence are those of cassiterite, galena, and other ores which are found in association with granitic intrusives near the western end of the peninsula and which have recently been described by Adolph Knopf.

While the types of mineral occurrence might be multiplied, for they include copper, antimony, tungsten, and other ores, what has been stated is sufficient to show that there is great variety in the form of mineralization. It also indicates that, in spite of the fact that there is now but little lode mining there is sufficient ground to believe that such an industry may be developed as to make it necessary to take it into account in estimating the gold reserves.

Though the Seward Peninsula auriferous gravels have been far more prospected than those of the Yukon-Tanana region, yet quantitative data of their gold contents are exceedingly scant. These data, however, were carefully compiled some years ago, and deductions made from them regarding the placer-gold reserves. Estimates were made by two different methods. By one the gold contents of auriferous gravels was valued at $265,000,000; by the other, $325,000,000. It can not be too often repeated that such computations are no more than mere approximations, for they are based on certain assumptions as to the gold tenor of the gravels, etc., which do not now admit of proof. These reserves appear to be two or three times as large as those estimated for the Yukon-Tanana region. This is due to the fact that in Seward Peninsula the data seemed to justify an attempt at an estimate of gold tenor for the entire body of auriferous gravels, while in the Yukon-Tanana region the information at hand only warranted an estimate of the auriferous gravels of the productive areas.

STATISTICS.

The systematic collection of statistics of gold production for Alaska was begun only in 1905, and the distribution of the output previous to that year is only an approximation. In the preparation of the following table the best available data have been used. In this table of production the Pacific coastal belt includes southeastern Alaska, the St. Elias region, and the Alaska Peninsula and adjacent islands, while under Copper River and Cook Inlet region are embraced the Kenai Peninsula and the Copper River and Susitna basins. The other geographical terms used in this table, Yukon basin and Seward Peninsula, need no definition.

Value of gold production of Alaska, with approximate distribution, 1880–1907.

Year.	Pacific coastal belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula.	Total.
1880	$20,000				$20,000
1881	40,000				40,000
1882	150,000				150,000
1883	300,000		$1,000		301,000
1884	200,000		1,000		201,000
1885	275,000		25,000		300,000
1886	416,000		30,000		446,000
1887	645,000		30,000		675,000
1888	815,000		35,000		850,000
1889	860,000		40,000		900,000
1890	712,000		50,000		762,000
1891	800,000		100,000		900,000
1892	970,000		110,000		1,080,000
1893	833,000		200,000		1,033,000
1894	882,000		400,000		1,282,000
1895	1,569,500	$50,000	700,000		2,328,500
1896	1,941,000	120,000	800,000		2,861,000
1897	1,799,500	175,000	450,000	$15,000	2,439,500
1898	1,892,000	150,000	400,000	75,000	2,517,000
1899	2,152,000	150,000	500,000	2,800,000	5,602,000
1900	2,606,000	160,000	650,000	4,750,000	8,166,000
1901	2,072,000	180,000	550,000	4,130,700	6,932,700
1902	2,546,600	375,000	800,000	4,561,800	8,283,400
1903	2,843,000	375,000	1,000,000	4,465,600	8,683,600
1904	3,195,800	500,000	1,300,000	4,164,600	9,160,400
1905	3,430,000	500,000	6,900,000	4,800,000	15,630,000
1906	3,454,794	332,000	10,750,000	7,500,000	22,036,794
1907	2,901,743	275,000	9,173,000	7,000,000	19,349,743
Total	40,311,937	3,342,000	34,964,000	44,262,700	122,935,237

Of this about $37,000,000 must be credited to the lode production, which is nearly all included in the Pacific coastal belt of the above table. Up to the close of 1907 there was only one productive auriferous lode mine in Seward Peninsula, and none either in the Yukon basin or in the Copper River and Cook Inlet region. The auriferous lode production, with the exception of that of the Apollo mine on Unga Island, southwestern Alaska, and a few small mines of the same general region, together with a small gold output from the copper deposits of Prince William Sound and from the auriferous lodes of Seward Peninsula, is all from southeastern Alaska. As the Treadwell group of mines has an output valued at $30,402,236, it will be seen that nearly five-sixths of the auriferous lode production is from this one ore body.

Accurate data regarding the source of the gold have been available only since 1906. They are summarized in the following table:

Source of gold in Alaska, 1906–1907, in values.

Kind of ore.	1906.	1907.
Placers	$18,607,000	$16,491,000
Siliceous ores	3,348,943	2,764,895
Copper ores	80,851	93,858

This table indicates that the placer production now overwhelmingly dominates in the total of gold output. This has, however, only been true since 1897, for previous to that time only about a third of the annual gold production was from the placers.

SUMMARY AND CONCLUSION.

It has been shown that gold is very widely distributed in Alaska, both in lodes and in placers; also that the production of the lode mines, outside of the Treadwell group, is insignificant. This does not mean, however, that the outlook for auriferous lode mining is not hopeful, for this is far from being the case. Up to the present time the cost of mining, except along a part of the Pacific seaboard, has been practically prohibitive for a lode-mining industry which is not based purely on the exploitation of bonanzas. Even along the seaboard there has been little systematic search for lodes. Most of the gold ores which have been found in the inland region have been of so low a grade as not to encourage their exploitation under present conditions of transportation. It will be clear, therefore, that there is no basis whatever for a quantitative statement of the gold reserves in the lodes of the Territory.

The known wide distribution of placer gold augurs well for future discoveries of this type of deposit. Most of the districts where mining operations are now going on have been so little prospected that little is known of their gold reserves. Some estimates, however, have been made for placer-gold reserves of the Yukon-Tanana region and Seward Peninsula. Those of the first province were made to include only the producing areas, while in Seward Pensinsula the bulk and value of the entire body of auriferous gravels was estimated. In the Yukon-Tanana region, which includes much the largest auriferous area, the gold contents of the producing part of the field are approximately valued at $100,000,000, not including the very large unprospected areas, while the auriferous gravels of the entire Seward Peninsula are estimated to contain about $300,000,000. It can not be too strongly emphasized that though all the data have been carefully compiled and the computations made with great care, yet there are so many unknown factors that the results are little more than guesses. No quantitative data of any kind are available for the other smaller districts, ten in number, but it is probably safe to estimate the gold in them as between $50,000,000 and $100,000,000. These values total about $500,000,000, which is the nearest approximation that can be given of the gold-placer reserves of the Territory. It is not impossible, however, that the Yukon-Tanana region alone may carry this amount of gold.

SILVER, LEAD, AND ZINC.

The silver production of Alaska has practically all been won incidentally to gold mining, and much the larger part of it has been recovered from the placer gold. There has also been a small recovery from the copper ores.

The total production of silver from 1880 to 1907, as nearly as can be determined, was 1,677,159 ounces, of which over three-quarters was from the placer gold. The following table shows the source of silver for the period that statistics have been available:

Source of silver from Alaska, 1906–7.

Kind of ore.	1906.	1907.
	Ounces.	*Ounces.*
Placers	76,835	40,847
Siliceous ores	15,772	14,653
Copper ores	18,577	34,357

There has been no lead production from Alaska, except a few tons recovered in the reduction of other ores. Galena is widely distributed, and some promising ore bodies have been prospected, but nothing is known of their extent. Such galena deposits occur in southeastern Alaska, on Prince William Sound, and in Seward Peninsula. Though attempts to exploit a galena ore body on Seward Peninsula date back to 1881 and have been continued intermittently to the present time and some small shipments have been made, this mine, called the Omalik, has never been on a commercial basis. The same statement applies to the mining of galena ores in other parts of the Territory.

Zinc blende has been found at a number of localities in Alaska, but the value of the ore bodies remains to be proved. No attempt has been made to mine zinc ores.

There are no data at hand on which to base any estimates of the reserves of the three metals here under consideration. With the increase of the gold output there will be a corresponding increase in the silver production.

COPPER.

DISTRIBUTION AND OCCURRENCE.

Copper ores are known to occur in commercial quantities on Prince of Wales Island (southeastern Alaska), Prince William Sound, and in the Chitina Valley of the Copper River district. They have also been found in a belt running from the Nabesna to the upper White River, in the Lake Iliamna region, and on the Seward and Kenai peninsulas. In these no ore bodies of proved commercial importance have been opened up, but the outlook for such in some localities appears hopeful.

On Prince of Wales Island, according to C. W. Wright, the copper ores, which are sulphides, occur along the contact of intrusives and limestones. U. S. Grant's description of the copper ores of Prince William Sound shows these to be sulphide ores which occur as lenses along shear zones. These shear zones are in greenstones or in contact zones between greenstones and graywackes. The Chitina belt, according to F. H. Moffit, includes both native and sulphide copper deposits. These occur at or close to a contact between a heavy greenstone (altered lava) and a limestone. This contact, along which mineralization seems fairly persistent though ore bodies of proved value have been exposed at only a few localities, has been traced for upward of a hundred miles.

The Nabesna-White River copper belt is of a similar character to that of the Chitina Valley, though here the value of the ore bodies found remains to be proved by further development work. In the Iliamna Lake region copper ores are said to be similar in occurrence to those of southeastern Alaska. Little is known of the other copper-bearing localities of the Territory.

STATISTICS.

Copper mining was first attempted on Prince of Wales Island in 1880, but the project was soon abandoned. The industry was begun again in 1900 in Prince William Sound, and five years later the Prince of Wales Island deposits also began producing. The total output of copper from Alaska up to the close of 1907 was 20,843,352 pounds, of which 12,368,975 pounds came from the Prince of Wales Island mines and the balance from Prince William Sound.

SUMMARY.

It is impossible to make any estimate of the tonnage of copper-ore reserves of the Territory. The developed ore bodies have been computed in a few mines by the operators, but even if these figures were available they would have little bearing on the problem of the ultimate reserves. Less than a score of copper mines have been opened up in Alaska, and all but one of these are located in two districts. In one promising district there has been only a little surface prospecting and this also holds true of the several widely distributed copper deposits which are not included in the four best-known districts. Even in the largest mines the workings in few cases extend to a depth of more than one or two hundred feet. It is evident, therefore, that the ore blocked out in the mines, whose copper content is probably less than 200,000,000 pounds of metal, has little bearing on the question of ultimate reserves, for it would not take into account either the undeveloped ore bodies already found or the possibilities of discoveries in the little-prospected fields. Moreover, any estimate of tonnage could include only the ores which can be mined at the present price of copper, while an increase of this price would make available lower-grade ores which can not now be commercially exploited. The problem is furthermore complicated by the irregularity of many of the copper deposits.

There can be no doubt that the output of copper from the Territory will increase during the next few years. The accessibility and cheapness of exploitation of the ores of the Pacific coast province invite copper-mining enterprises, in spite of the irregularity of occurrence of most of these deposits. A railway is now under construction up the Copper River valley which will not only lead to early shipments of a large amount of copper ores from the deposits already found, but will also stimulate further search and probably lead to the discovery of other ore bodies.

WATER RESOURCES.

INTRODUCTION.

The principal value of the water resources of Alaska is for generating power to be used for mining, now the only extensive industry. There are two general methods of utilizing the water power: (1) By converting it into electricity or other form of energy, for the purposes of lode and placer mining. By such means the power can be transmitted to the locality of use. This form of utilization is now almost entirely confined to the Pacific coastal belt of the Territory. (2) The more direct use of the water under head for sluicing, elevating, and hydraulicking the auriferous alluvium. This second form of utilization has been extensively practiced in small plants throughout the placer districts.

Many of the gold placers and lode deposits can be profitably exploited only by the utilization of water power. The water powers are also valuable to other industries, but up to the present time have not been so utilized, except in a small way for running electric-light plants, machine shops in some of the coastal towns, and some fish-product manufactories.

An adequate knowledge of the distribution, volume, and gradients of the surface water is, therefore, of first importance to the industry of the Territory. The underground waters of Alaska need not here be considered; none such have been developed and little is known about their occurrence. There is a possibility that in some of the placer districts there may be underground waters in sufficient quantity to justify their development for purposes of supplementing the inadequate surface waters. Artesian waters have in a few instances been found underneath the layer of perpetually frozen ground. These appear to be exceptional conditions, as usually the frost extends all the way to bed rock. Such ground waters, where they have been found, are probably very local in extent. There are also some potable waters derived from springs, but these, as well as the surface water used for towns, need not here be considered.

Facts regarding the water supply are scant and based almost entirely on the results of the investigations of the United States Geological Survey. These results are of two kinds—(1) the records of stream gaging, which furnish information as to the volumes of the watercourses, and (2) the topographic maps, which show the distribution of the water, as well as the gradients of the streams in which it flows. Measurements of stream flow have been carried on for three seasons (1906–1908) in some of the important placer districts of Seward Peninsula, for two seasons (1907–1908) in the Fairbanks district, and for one season (1908) in the Hot Springs, Rampart, and Birch Creek districts. These measurements furnish the only data on stream volume throughout the Territory, though a few corporations have obtained records from small areas preparatory to the installation of hydraulic plants.

The topographic data are more complete, for reconnaissance maps (scale 1:250,000, with 200-foot contours) of some 121,252 square miles have been made which cover most of the important mining districts and about 20 per cent of the entire area of Alaska. These reconnaissance maps furnish a general conception of drainage basins and stream gradients. In addition, 2,732 square miles have been mapped in detail (scale 1:62,500, with 25, 50, or 100 foot contours), yielding accurate information of the extent of drainage basins and of stream gradients.

Only two of the larger geographic provinces of Alaska will here be considered, namely, (1) the Pacific coastal region and (2) the central region, for, as far as can now be foreseen, it is only in these two that the water has any industrial value. These two provinces differ essentially in climate and relief and, indeed, present almost the extreme conditions as regards the occurrence and utilization of surface waters. In the coastal belt as a whole the topography is extremely rugged and many of the streams are fed by perennial snows, which, together with the large precipitation (75 to 120 inches), yield a large run-off with no great fluctuations during the summer months.

Beyond the coastal barrier the climate is semiarid (precipitation 10 to 20 inches), the relief is weak, and hence stream gradients are low, while there is no permanent snow. Another feature of the precipitation is that summer rainfall is very local. Moreover, the general frozen condition of the subsoil to bed rock probably prevents any considerable ground storage. These conditions make for a small run-off per square mile and very marked fluctuations in stream volumes. Moreover, the low relief makes it difficult to utilize the water under head.

Seward Peninsula, though not strictly a part of the central region, possesses the same general hydrographic conditions. The precipitation (10 to 30 inches), however, averages a little greater than in the Yukon basin. Here also the low stream gradients make much of the run-off unavailable for placer mining.

The conditions affecting surface waters in the area drained by Susitna and Copper rivers differ somewhat from those existing in the Pacific coastal region and in the inland province. In part this area has as strong relief as that along the seaboard, yet its precipitation is far less. On the whole, however, this region is better supplied with water than the Yukon basin.

PACIFIC COAST REGION.

In southeastern Alaska alone has there been any considerable utilization of water power. The Census Bureau collected the statistics of the developed water power in this part of the territory. Through the courtesy of the Director of the Census the following data are available. The statistics show that a total maximum of 15,699 horsepower has been developed and that 100 water wheels have been installed. Of this maximum 2,816 horsepower is available during low-water season. It is reported that at the localities where this power has been developed there is 14,135 horsepower available. Of the developed horsepower 3,403 horsepower is utilized by electric-light plants, canneries, and some other small industrial enterprises, and the rest by mining and smelting plants. The Treadwell group of mines alone utilizes some 6,647 horsepower. In addition to the above a few hunded horsepower is developed in other parts of the Pacific coast belt.

Southeastern Alaska affords conditions which are peculiarly favorable for the development of water power. The glaciation of this region has developed a topography which, with its cirques and many lakes lying at considerable altitude above sea level, is favorable to water storage. While the run-off during the summer months is much larger than during the winter, yet there are many localities where a large amount of power can be developed, even during the low-water stages.

YUKON BASIN.

There are no records which make it possible to state the quantity of water used for placer mining in the various Yukon districts, but it is known to be a large amount. Nor has stream gaging progressed far enough to determine the available water. However, it is probably safe to say that within a few years every supply so situated as to be directly applicable to placer mining will be utilized. Even when this has been brought about, the supply will be inadequate for the gold placers already opened up. In addition to this water directly applicable to placer mining, there are a number of water powers which can be utilized for certain mining operations by transformation to other forms of energy. It is probable that even after the development of these water powers the demands of future mining interests will not have been met. The utilization of coal to supply this demand is discussed elsewhere in this report. Mention should be made in this connection of the possibility of developing power along the streams which find their source in the high mountains stretching along the southern margin of the Yukon basin. These streams have not been measured and but few have been surveyed. They are known, however, to have a much larger volume than those of the central region proper, and the topography would appear to be favorable to water-power development. Some of the important placer districts lie within 50 or 100 miles of the mountain front.

The following table, which is based on the investigation of Mr. Covert, presents in summary form the available data regarding the run-off in the districts which have been investigated. It can not be too strongly emphasized that, as this is based on only one or two seasons' observations, the data presented are only an approximation.

Estimates of mean annual discharge and run-off of drainage basins in Yukon-Tanana region, Alaska.

[By C. C. Covert.]

District.	Year.	Second-foot per square mile.	Depth in inches.	Per cent estimated.[a]	Duration of record.	
					From—	To—
Fairbanks, 826 square miles	1907	0.780	10.60	62	June 20	Oct. 15
	1908	.710	9.66	54	May 1	Oct. 21
Mean		.745	10.13	58		
Hot Springs, 56 square miles	1908	.44	6.00	95	June 6	Sept. 28
Rampart, 212 square miles	1908	.54	7.40	90	...do....	Do.
Circle, 2,150 square miles	1908	.99	13.50	91	June 26	Oct. 13

[a] The run-off for the period not covered by records was estimated at approximately 0.25 second-foot per square mile.

SEWARD PENINSULA.

What has been said of the Yukon basin applies also to Seward Peninsula. Here, too, nearly all the water available for direct application to placer mining will soon be utilized, and even then can not meet the demand. Some important undeveloped water powers are known to exist in this province.

The topography of Seward Peninsula, like that of the Yukon basin, is of low relief, and therefore a comparatively small part of the run-off can be made available for mining. In the mountain mass, including the Bendeleben and Kigluaik ranges, the conditions for water storage are somewhat more favorable than in other parts of the peninsula. Here there are some glacial cirques, and though these are of comparatively small extent, they have an influence in the conservation of water and snow. What is of still greater importance, however, is the greater rainfall which occurs in these high mountains compared with other parts of the peninsula.

Mr. Henshaw has summarized his three seasons' observations on stream flow in Seward Peninsula in the table which follows. The value of the data contained in this table will be increased by considering the character of the topography of the basins whose run-off is given. Kruzgamepa River, at Salmon Lake, drains a basin typical of the Kigluaik and Bendeleben mountain areas. Kuzitrin River and Imuruk Lake lie in the northern portion of the peninsula and represent the area north of the mountains. There are not sufficient data to make any estimate of the yearly run-off from the country south of the mountains.

Estimates of mean annual discharge and run-off of drainage basins in Seward Peninsula, Alaska.

[By F. F. Henshaw.]

Stream.	Year.	Second-feet per square mile.	Depth in inches.	Per cent estimated.	Duration of record.	
					From—	To—
Kruzgamepa at Salmon Lake, 81 square miles	1906	3.68	50.2	38	May 28, 1906	Sept. 30, 1906
	1907	3.77	51.1	40	June 15, 1907	Oct. 5, 1907
	1908	2.40	32.6	63	June 21, 1908	Sept. 30, 1908
Mean		3.28	44.6	47		
Kuzitrin at Lanes Landing, 1,720 square miles	1907	.46	6.2	100		
	1908	.39	5.3	40	June 1, 1908	Sept. 30, 1908
Mean		.42	5.7			
Imuruk Lake, 99 square miles	1906-1907	.59	7.9		Aug. 16, 1906	Aug. —, 1907
	1907-1908	.50	6.8		Oct. —, 1907	Sept. 25, 1908
Mean		.54	7.4			

The discharge of Kruzgamepa River at Salmon Lake has been assumed to decrease regularly from October 1 to a minimum of 30 second-feet on April 20, then to increase slowly until the break-up of the ice, and more rapidly until the date of the beginning of records, which has been taken as the maximum for the year. The run-off from snow for 1908 was taken as 70 per cent of the mean of that for the two previous years.

The run-off of Kuzitrin River for May, 1908, was taken as 75 per cent of that for June, and for the remainder of the year as 0.06 second-feet per square mile. The run-off for 1907 was estimated by comparison with the two years' record at Imuruk Lake. The flow into Imuruk Lake was determined by closing the dam at the outlet and noting the rise of the water surface.

WASTE OF STRUCTURAL MATERIALS FROM FIRE AND OTHER CAUSES.

By Herbert M. Wilson,
United States Geological Survey.

The mineral structural materials may be divided into two classes:

(*a*) Iron, steel, copper, and other metallurgical products, the supplies of which are limited and which are themselves subject to destruction through weathering, fire, etc., and

(*b*) Stone, clay products, and cement and concrete manufactures, which are less subject to destructive agencies and the supplies of which are practically inexhaustible.

The substitution of the latter materials for the more commonly used wood and metal manufactures should be encouraged as having an important influence on the preservation of the supplies of the more perishable and less abundant materials. The use of building stone, clay, and cement products in this country has been restricted by competition with the much cheaper wood products and the more easily fabricated and more available metal products. Improved methods of preparing the raw materials for use in building construction are rapidly reducing this difference in cost, and careful investigation both as to the physical properties and the more suitable structural forms should have an important influence on further reducing this difference in cost and the enlargement of the use of the more permanent and less perishable materials.

The value of the cement manufactures has increased from $9,859,000 to $55,803,000 within the last decade, or nearly sixfold. The value of the clay products has increased in the same time from $74,487,000 to $185,942,000, or over double, while the building stone has in the same period increased in value from $28,635,000 to $71,106,000, or nearly three times. As the Government, through its investigations, is determining the strength, durability, and fire-resisting properties and the more suitable forms of these materials and disseminating information relative to the comparative cheapness and greater permanence of such materials, a still greater relative increase in their use may be confidently looked for in the near future.

Within the past few years marvelous strides have been made in the substitution of iron and steel for wood, owing to the careful investigations into their properties made by engineers, physicists, and chemists and the great amount of attention given their fabrication by manufacturers and architects. More recently the engineering and technical professions have advanced to a great extent the uses of cement and concrete manufactures; but in a vastly greater period of time practically nothing has been done toward ascertaining the physical and chemical properties and better mode of manufacture and use of the products of clay and stone. Undoubtedly great progress in the substitution of all of these materials for metal and wood in building construction may now reasonably be looked for, with proper encouragement from the Government as an exemplar in the methods of testing and assembling such materials.

WASTE OF STRUCTURAL MATERIALS.

The waste of natural mineral resources used in building and engineering construction is of three kinds:

(1) That due to improper and wasteful methods of mining and preparing for market.

(2) That due to excessive use in structural forms, because of ignorance of the strength, durability, etc., of the materials used.

(3) That due to destruction by fire on account of the inflammable character of building construction, inadequate building laws, and the nonenforcement thereof.

The waste of raw mineral products due to improper methods of mining and shipping is fully discussed elsewhere in this report. There is an equally large waste of these materials due to uneconomical and inefficient methods of manufacture, including waste of the fuel, as in the preparation of coke used in refinement of iron ores and of fuel used in burning cement, clay products, etc. Not until a better knowledge is had as to the appropriate structural material, be it steel, iron, stone, cement manufactures, or clay products for any particular purpose, will it be possible to reduce a portion of this wasteful consumption.

Most of the information available concerning the strength and suitability of such materials has been procured by individuals, based on insufficient data and tests. The Government, as the largest consumer of such materials, should, as a matter of economy, conduct exhaustive tests of the kinds which have proven so successful under the Forest Service in developing the most suitable woods for each particular use. These tests should be conducted with a view to establishing the physical properties of these materials and to suggesting improved methods of manufacture which may prove not only economical, but shall improve the quality of the materials in use and extend their life. These investigations should include the assembling of information relative to the most fire-resisting and fireproof forms of construction, the former having in view the prevention of conflagrations due to secondary or exposure fires, and the latter the prevention of the destruction of the building in which the fire may originate. They should also include extended investigations with a view to preventing the loss of structural materials exposed to the action of salt water, the action of alkalies in the arid regions, and to similar destructive agencies.

A great many structural materials are used in excessive quantities in the erection of buildings and engineering works, while materials of superior quality may be little used because of lack of information as to their properties. The average architect, engineer, or contractor does not take chances of using unfamiliar materials or designs, but confines himself to those he has knowledge of as having proven moderately successful. Authoritative investigations should be made of such materials with a view to establishing the strength and properties of each under varying conditions, and of pointing out the most economical material for each use. The present systems of building construction are expensive and wasteful, because of lack of exact knowledge as to the strength of the materials when fabricated into various forms of construction.

The investigations so far conducted by the Geological Survey indicate the local availability of gravel, sand, or broken stone suitable for making concrete or reenforced concrete structures, where it had been previously assumed that such materials were not suitable and the charge for haulage from distant quarries often rendered the cost of such construction excessive. A better knowledge of the distribution of these constituent materials of concrete, and of the building stones and clays locally available, will encourage the use of these durable structural materials in competition with forest products and other less permanent materials, thus conserving the latter.

The use of excessive quantities of structural materials, due to ignorance as to their strength, results from the very incomplete tests regarding such strength, in the absence of which conservative designers use an unnecessarily large factor of safety. Engineers and architects adopt working stresses for metal and reenforced concrete of from one-fourth to as high as one-eighth the supposed working strength of the material, which may mean that from three to six times the amount of material that is necessary is being used. But lighter designs can not safely be adopted until absolute knowledge is had, through long series of tests and investigations, which will thoroughly establish the strength and durability of each structural material for the specific purpose for which it is to be used.

As shown elsewhere in this report, the iron resources of the world, and those of the United States in particular, are not limitless. According to the present ratio of increase in consumption of iron and steel products, the supply of these materials in the United States will be exhausted in a few centuries. The forest products of the United States are rapidly approaching exhaustion, and unless immediate means be taken to limit their waste and reproduce their growth, a fraction of a century will see their exhaustion. Under the circumstances, we must turn to concrete-making materials, such as cement, sand, and gravel, to the raw clay from which brick and tile are manufactured, and to building stones, the amounts of all of which in the United States are practically unlimited, as substitutes for the above more perishable materials.

FIRE LOSSES.

The greatest source of waste of structural materials and of money values in the United States is that due to fires and this is one which from the example set in European countries can, as hereafter shown, be most greatly reduced by the substitution of fire-resisting building materials for the inflammable construction now so prevalent.

The cost of fire to the country, including not only property destroyed, but maintenance of fire departments, payment of insurance premiums (less benefits returned), protective agencies, additional cost of city water supplies to meet fire drafts, etc., amounted to over $456,-

485,900 in 1907. This fire tax exceeded the total value of the gold, silver, copper, and petroleum production of the United States in 1907 and was thirteen times the interest on the national debt. The property loss from fires in the United States in 1907 was $2.51 per capita. The total per capita loss, including interest and maintenance charges on fire departments, excessive water supplies, insurance premiums, etc., was $5.34.

In addition, 1,449 persons lost their lives in fires during the year 1907, while 5,654 were injured. The loss of life during 1908 was even greater, on account of the Boyertown (Pa.) opera-house fire and the Collingwood (Ohio) school disaster. Undoubtedly the greater part of this immense waste in material, money values, and lives could be prevented by the use of suitable structural materials and the better fabrication of these into building construction. Such construction would cost little more than the present combustible building, and would result in real economy in the long run, and in the extension of the life of the mineral and forest resources.

Possible means of reducing this enormous waste due to fire and conflagration are:

(1) By tests and investigations to determine the relative fire-resistive properties of building materials, the relative rates of heat conductivity of such materials, and the developments of systems of construction which offer the maximum resistance to fire. These tests should have in view the classification in order of merit of the building materials and the cheapening of cost of construction by the use of those best suited to the purpose, since materials actually cheaper are often not employed through lack of knowledge of their available properties.

(2) By the dissemination of information regarding the less inflammable materials of construction, their strength and durability, the methods of utilizing them in building construction, and the availability of the most suitable of these materials near the locality in which they are wanted.

(3) By the enactment of building codes and the enforcement of the same with a view to securing more fire-resistant and more fireproof construction. In European cities the erection of wooden buildings is prohibited, and the official supervision of brick, stone, steel, and cement construction is such as to diminish danger from fire due to defective flues, poor electric wiring, etc., and as to confine the fire to the building in which it originates.

The fire waste in the United States for the year 1907 reached the enormous total of $456,485,900, exclusive of forest, mine, and marine fires. Of this total $109,156,894 was due to the destruction of buildings and $105,927,815 to the loss or injury of contents. A noteworthy fact is that of this loss 27 per cent was due to exposure, i. e., the fire extended beyond the building of origin. This loss is quite evenly distributed between urban and rural districts; the loss in cities amounting to $107,093,283, and in villages and the country $107,991,426, and as the urban and rural population are almost exactly equal the per capita loss in each division is very evenly divided. Only $68,000,000 of this loss was on brick, iron, stone, and other slow-burning constructions, while over double this amount, or $146,000,000, was on frame buildings. In the last thirty-three years the total fire waste, being the value of property destroyed, amounted to over $4,484,000,000, while the total cost of such fires doubtless aggregated double this vast sum.

Even where frame buildings are permitted or are now in existence, the loss might be greatly reduced by more careful oversight over defective flues, wiring, etc.

The cost of insurance amounted to $145,604,344, being the difference between the total premiums paid on policies, $259,768,813, and the benefits paid to the insured, $114,164,469. The cost of fire-department maintenance and interest on capitalization amounted to $44,237,100 of the total. The interest on the capital cost of fire-protective devices, such as automatic sprinklers, fire extinguishers, etc., and the annual cost of private watchmen's service, etc., amounted to about $18,000,000. The total for the year 1907 is swelled by the amount invested in city water-supply service and distributing systems primarily necessary for fire protection and over and above that estimated as necessary for domestic consumption. This includes interest on the capital invested in city fire protection, $9,826,800, and maintenance charges, $8,465,500, the sum of which aggregates about 22 per cent of the total cost of water supply. The depreciation charges and taxes on all the above amounted to $15,167,500.

A large portion, probably over one-half of the insurance, one-fourth of the city water-supply and distribution charges, one-half of the fire-department charges and three-fourths of the fire losses, or a total of $234,196,956 per annum, may be reasonably expected to be saved, when through the dissemination of information relative to less inflammable structural materials and the enactment of better building codes, building construction in the United States shall become of a kind similar or superior to that now found in European countries.

HOW THE STATISTICS WERE GATHERED.

The details making up the above summary of fire losses of structural materials and property values, as well as the invested capital, are submitted in the following tables and discussion, chiefly the work of John L. Cochrane, statistician, assisted by Frank D. Brown:

At the request of the National Conservation Commission, the United States Geological Survey, through its technologic branch, took up the task of gathering the statistics of fire losses of the country. Requests for the official records of fire loss were sent to the chiefs of fire departments in 5,175 incorporated places in the United States (all places of 1,000 population and upward) with the result that 1,000 replies were received. Four thousand second requests were sent out, and to these 1,796 fire chiefs responded, making a total of 2,796 cities and villages heard from out of 5,175.

These cities and villages, with a population aggregating 34,102,453 reported a fire loss of $86,476,029, or a per capita loss of $2.54.

It was with the greatest difficulty that figures were obtained showing separately the losses on frame and brick buildings, on buildings and contents, and losses on buildings in which fire did not originate, since many of the fire chiefs merely sent an estimate of the total loss. After much correspondence, 2,300 out of the 2,796 chiefs who replied originally gave the detailed figures.

In order to obtain a correct estimate of the losses in the rural districts, 5,000 blanks were sent to postmasters located in counties that were strictly rural, the aim being to exclude all counties that contained villages of any sizes whatever. The blanks were apportioned among the various States according to their percentage of rural population, the States with a large farming population getting more than the States whose population centered mainly in the cities. Responses were received from 1,898 postmasters representing a population of 1,410,383. These postmasters reported a total loss of $3,519,769, which gives a per capita loss of $2.49.

Thus it will be seen that reports were received from 4,694 cities, villages, and rural communities with a total population of 35,512,836 and a total loss of $89,995,798, a per capita loss for the entire United States of $2.51, or an aggregate loss for the United States of $215,084,709.

The only statistics with which these are comparable have been gathered by the National Board of Fire Underwriters. This organization, composed of the leading fire underwriters of the country, has given out estimates of the fire losses for several years, in the hope of showing the public how much of the loss is preventable and with a view toward creating a public sentiment in favor of better building construction.

In order to ascertain the additional cost imposed upon the country by fires over and above that represented by simple fire waste or destruction of property and the cost of public fire-fighting departments and systems and insurance losses above referred to, careful statistical inquiry was made into the additional cost of construction and maintenance of city water supplies necessary on behalf of protection against conflagration over and above cost pertaining to domestic supply, street sprinkling, and the incidental fire service necessary to restricting a fire within the building of origin. Information was also procured regarding the cost of private fire-protective measures such as automatic fire sprinklers, fire extinguishers, and grenades, private watchmen's services, etc., imposed by the risks due to inflammable construction. Finally, an attempt was made to ascertain the losses to the country from marine fires and disasters. The statistics regarding public water supplies were secured by correspondence and the submission of questions to the superintendents of water supply in every city in the United States and to the more prominent hydraulic engineers. In all, 5,700 blank report forms were sent out to which 1,500 replies were received, of which, however, but a small percentage was complete enough for tabulation. The total cost in each case was obtained from the census reports for cities of above 30,000 population owning waterworks and the remainder from the Spectator.

This total cost of waterworks systems in the United States was segregated to show the total cost in each of the five geographical divisions of the United States, viz: The Middle Atlantic and New England States; the Southern and Southeastern States; the Central States; the Rocky Mountain or arid region; and the Pacific Slope States.

The total cost of the waterworks systems in each of the geographical divisions was then subdivided to show the total cost in cities according to the following classification: Population of 100,000 or over; population of 30,000 to 100,000; population of 5,000 to 30,000; and population under 5,000.

This same plan of classification was pursued in tabulating the reports received from engineers and superintendents who gave in detail the information sought. This detailed information for each geographical division and classification by size of cities was then applied to the total cost of waterworks systems for the corresponding geographical divisions and classifications by size of cities, and the same proportionate distribution made for the various inquiries.

The procurement of data of losses from marine disasters was even more difficult than the above. This was arrived at by securing the total paid by American companies and the total paid by foreign companies doing United States business, giving an aggregate total for the year 1907 of $11,621,827. It is not evident that a portion of this may not include some Canadian insurance or cover some duplication. Endeavors to secure data on cost of private fire protection were even less successful. Information received from the manufacturers of automatic sprinklers, fire extinguishers, etc., and estimates of the cost of private watch service derived from special investigations in a number of prominent cases lead to the belief that the invested capital, including construction, equipment, etc., aggregates about $50,000,000, while interest upon this amount and the cost of watchmen's services, etc., would amount to an annual charge of about $18,000,000.

FIRE WASTE.

The total loss from fire in the United States during 1907, $215,084,709, represents a waste of nearly $600,000 for every day of the year, or $25,000 for every hour of the day. The term "waste" is used because the fire loss is one that is absolutely irretrievable, and constitutes a tremendous drain upon the natural resources of the country. The insurance on a burned building does not bring back the property that was destroyed—it simply equalizes the loss between all others whose property is insured—and the money paid by the insurance companies does not by any means cover the total losses sustained. Underwriters declare that from 75 to 80 per cent of all property is insured, but two State fire marshals disagree with this statement after tabulating the fire losses for their States. The State fire marshal of Ohio, D. S. Creamer, finds that but 52 per cent of the property is covered by insurance. This statement seems to be borne out by the annual report of the National Board of Fire Underwriters for 1907, which gives as the total losses paid by all companies during the year $114,164,469.

The fire waste for the last thirty-three years, according to the National Board of Fire Underwriters, reached the tremendous total of $4,484,326,831.

Fearful as it is to contemplate this great destruction of the natural resources of this country, the situation becomes more appalling when it is realized that this waste is rapidly increasing. The National Board of Fire Underwriters gives the following estimates of the fire waste for the last thirty-three years:

Annual fire losses in the United States for thirty-three years, 1875–1907.

[Compiled by the National Board of Fire Underwriters.]

Years.	Aggregate property loss.	Years.	Aggregate property loss.	Years.	Aggregate property loss.
1875	$78,102,285	1886	$104,924,750	1897	$116,354,575
1876	64,630,600	1887	120,283,055	1898	130,593,905
1877	68,265,800	1888	110,885,665	1899	153,597,830
1878	64,315,900	1889	123,046,833	1900	160,929,805
1879	77,703,700	1890	108,993,792	1901	165,817,810
1880	74,643,400	1891	143,764,967	1902	161,078,040
1881	81,280,900	1892	151,516,098	1903	145,302,155
1882	84,505,024	1893	167,544,370	1904	[a] 229,198,050
1883	100,149,228	1894	140,006,484	1905	165,221,650
1884	110,008,611	1895	142,110,233	1906	[b] 518,611,800
1885	102,818,796	1896	118,737,420	1907	199,383,300

[a] Baltimore conflagration.
[b] San Francisco earthquake and conflagration.

ANALYSIS OF LOSSES IN THE UNITED STATES.

The following table of the fire losses in the United States in 1907 gives a number of interesting comparisons of the total losses sustained in the cities and in the rural districts:

Fire losses in the United States for 1907.

[Statistics gathered by the United States Geological Survey.]

	Total.	Urban.	Rural.
Fire loss:			
Buildings	$108,156,894	$50,173,625	$58,983,269
Contents	106,927,815	56,919,658	49,008,157
Total	215,084,709	107,093,283	107,991,426
Brick, etc.:			
Buildings	31,092,687	19,816,474	11,276,213
Contents	37,332,580	29,092,270	8,240,310
Total brick, etc	68,425,267	48,908,744	19,516,523
Frame:			
Buildings	78,064,207	30,357,151	47,707,056
Contents	68,595,235	27,827,388	40,767,847
Total frame fire loss	146,659,442	58,184,539	88,474,903
Number of fires:			
In brick, etc., buildings	36,140	25,297	10,843
In frame buildings	129,117	80,109	49,008
Total number of fires	165,257	105,406	59,851
Loss per capita, United States	2.51	2.54	2.49

It will be seen that the loss is rather evenly divided between the urban and the rural population, the total loss in the cities and villages amounting to $107,093,283, and in the rural districts to $107,991,426. The total urban population is estimated at 42,160,710, and the rural at 43,162,051. The big losses in the cities and villages are not surprising, for in these are located many large buildings filled with millions of dollars worth of property; buildings which are subjected to additional risk because they adjoin one another or are near each other. In the rural districts the buildings are widely separated and contain property that does not compare in value with that in the cities, yet the losses are as great in these districts. The only conclusion that can be drawn from this condition is that the remarkable efficiency of the fire departments of the cities prevents a loss much greater than occurs, and that the absence of fire-fighting apparatus in the rural districts permits the loss in fires to be total.

This fact is plainly shown in the total building loss of the country, the fire departments keeping the loss in cities and villages down to $50,173,625, while fires in the rural districts consumed buildings valued at $58,983,269.

The contents loss in the cities and villages was $56,919,658, as against $49,008,157 in the rural districts; which again proves the contention, in spite of the great loss in the rural districts, as it is well known that the value of the property in city buildings is many times greater than that in buildings in rural communities.

The losses on brick, stone, and steel buildings in cities and villages amounted to $19,816,474, and on contents, $29,092,270; in the rural districts the losses on these buildings were $11,276,213, and on the contents, $8,240,310. The much heavier losses in the cities and villages on the brick, stone, and steel buildings are undoubtedly due to the few buildings of this character in the rural districts in comparison to the number in the cities.

The losses on frame buildings in the cities and villages amounted to $30,357,151, and on the contents to $27,827,388. In the farming communities the losses on these buildings reached a total of $47,707,056, and on the contents $40,767,847. This once more tells of the efficiency of the fire departments in coping with the flames in cities and villages and the utter lack of fire protection in the rural districts.

CAUSE OF FIRE WASTE IN THE UNITED STATES.

The great fire waste in the United States is undoubtedly due to the predominance of frame buildings. In most European cities frame buildings are positively prohibited within the limits of the municipalities, and but few are erected in the rural districts, owing to the scarcity and high price of lumber. In the United States the conditions have been exactly reversed. Lumber, at least until recently, has been the cheaper material, besides being more easily worked than brick, stone, and steel. The result has been that a great majority of the homes of the country and many factory buildings, warehouses, etc., have been made out of lumber.

Of the total losses sustained in the United States in 1907, more than two-thirds were on frame buildings. The exact losses are, $146,659,442 in frame buildings and $68,425,267 in brick, stone, and steel buildings, as shown by the foregoing table.

Another illustration of the influence of frame buildings upon the fire loss of the country is suggested by grouping eleven States which are practically treeless and comparing them with eleven States in which there is still an abundance of timber, the argument being that there will be a greater proportion of frame buildings in the States where lumber is plentiful because of its cheaper price. The States in which there is a supply of lumber show an increased per capita of loss of 59 cents over the per capita of the treeless States, as seen by the following table:

The per capita fire loss for 1907 in 11 States where timber is scarce and in 11 States where timber is plentiful.

[Statistics gathered by United States Geological Survey.]

	Total population.	Total fire loss.	Per capita.
Group 1.—States having scarcity of timber:			
Iowa, Illinois, Oklahoma, Connecticut, Delaware, New Jersey, South Dakota, Rhode Island, Kansas, Nebraska, and North Dakota	16,785,460	$38,006,558	$2.30
Group 2.—Showing timbered States:			
Washington, Louisiana, Texas, Mississippi, Wisconsin, Arkansas, Michigan, Pennsylvania, Minnesota, Oregon, and North Carolina	25,560,533	73,895,950	2.89

A study of the fire losses of the United States from the standpoint of geographical division of the States—a division frequently used by the Census Bureau—gives interesting results. The remarkable feature is the per capita loss in the South Central States—Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Texas, Oklahoma, and Arkansas, $3.66—more than $1 in excess of the per capita of any of the other divisions. All of the States in this division have much timber; therefore, many frame buildings. These States also have the handcap of inefficient fire protection compared with the States of the North and East. The total and per capita losses according to geographical divisions of the States are as follows:

The per capita fire losses for 1907 in the United States as shown by geographical divisions of the States.

[Statistics gathered by U. S. Geological Survey.]

Geographical division.	Total population.	Total fire loss.	Fire loss per capita.
North Atlantic:			
Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Pennsylvania	23,779,013	$59,447,532	$2.50
South Atlantic:			
Delaware, Maryland, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida	11,574,988	25,349,223	2.19
North Central:			
Ohio, Indiana, Illinois, Michigan, Wisconsin, Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, and Kansas	29,026,645	68,793,148	2.37
South Central:			
Kentucky, Tennessee, Alabama, Mississippi, Louisiana, Texas, Oklahoma, and Arkansas	16,368,558	59,908,922	3.66
Western:			
Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, and California	4,783,557	12,676,426	2.65

While the prevailing material of construction—lumber—is largely responsible for the great fire waste of the United States, there is a cause lying back of all of this—faulty construction and equipment of buildings. The list of causes of fires is headed by defective chimneys, flues, fireplaces, and heating and lighting apparatus, all of them faults of construction and equipment. Matches, sparks, and explosions figure prominently in the list, followed by incendiarism, electricity, and lightning. Nearly one-fourth of the fires are labeled "unknown cause," which indicates forcibly the listless attitude toward this waste, not only of the general public, but also of the men directly charged with protecting property against fire—the officials of municipalities and others.

FIRE WASTE IN EUROPEAN CITIES.

In 1905 the Bureau of Manufactures of the Department of Commerce and Labor sent letters of instruction to all the principal United States consular officers in Europe requesting information concerning the fire losses of European cities; also a statement regarding the fire insurance practice in those cities. Unfortunately the statistics gathered were not all for the same year, some cities reporting for 1901, others for 1903, and still others for 1904, a few failing to make any report. It is claimed, however, that there is but little variation from year to year in the fire losses of European cities, and for this reason the figures were tabulated.

Cities of Austria, Belgium, France, Germany, Norway, Russia, Switzerland, and the United Kingdom, with a reporting population of 19,913,916, had a loss of but $9,582,340, a per capita of 48 cents. Russia had the highest loss, $3,100,823, in a population of 2,673,427, a per capita loss of $1.16.

If the United States had Europe's per capita of 48 cents, in a total population estimated by the Census Bureau for 1907 as 85,532,761, the total fire waste in this country for the year would amount to $41,055,725, a saving of natural resources to the extent of $174,028,984.

Taking the maximum per capita in Europe, $1.16 in Russia, and the fire waste in the United States would amount to $99,218,002, or $116,314,759 less than it did.

The principal reason for the great difference between the amount of fire waste in the United States and Europe is that there are but few frame buildings in Europe and practically none in the great cities.

Consul Hossfeld, of Trieste, Austria-Hungary, in his official report to the State Department on the fire losses in the city he represents, said:

> The laws of Trieste and its territory prohibits the construction of wooden buildings. Only sheds and buildings of a temporary nature may be constructed of wood, such as are intended to serve as a shelter for workmen or for the storage of materials while permanent buildings are being constructed.

Consul Harold S. Van Buren, of Nice, France, wrote:

> There may be a few sheds of wood or detached stables of a temporary character, but not sufficient to form a portion of the statistics.

Consul John C. Covert, of Lyons, stated:

> An official in the office of the mayor informed me that there are no wooden buildings in the city, except a few old sheds, constructed without permission and permitted to remain, as they are in open fields and of no danger, being some distance from other buildings.

Consul-General Frank H. Mason wrote concerning Berlin, Germany:

> The comparative immunity of Berlin from disastrous fires, results not from the efficiency of its fire department—although it does promptly and well what

work it has to do—but from the absence of wooden houses and the solid, careful construction of all kinds of stone and brick buildings under the rigid scrutiny of the building police.

The following statement is made in Special Consular Reports, volume 38, Bureau of Manufactures, Department of Commerce and Labor, in discussing the insurance in foreign countries:

> In Europe the fire insurance laws are remarkable, chiefly because they compel insurance in some countries, while in all cities they prevent great losses by insisting on the erection of only stone and brick buildings. The fire-department systems are ridiculously inadequate as compared with those of American cities, yet the net results are better. French law compels insurance against fire not only for the benefit of the owner, but for his neighbors. In Germany building insurance is compulsory and in some kingdoms it is a government monopoly. Russia has an elaborate system of central and local government insurance and compels all buildings to be insured. By a law recently enacted the Swiss method of insuring against the loss of time by fire has been made almost impossible. In some of the cantons insurance against loss by fire is compulsory.

The countries of Europe with their reporting city populations and fire losses are as follows:

Fire losses in cities of Europe.

[Statistics gathered by the Bureau of Manufactures.]

Country.	Population.	Fire loss.	Per capita.
Austria [a]	193,387	$72,355	$0.37
Russia [a]	2,673,427	3,100,823	1.16
United Kingdom [a]	4,319,816	1,795,750	.42
Belgium [b]	312,987	178,766	.57
Germany [b]	7,446,447	1,832,402	.25
Norway [c]	222,373	207,000	.93
Switzerland [c]	715,712	192,500	.27
France [d]	4,029,116	2,202,744	.55
Total	19,913,265	9,582,340	.48

[a] Losses for 1904.
[b] Some cities of country report for 1903; others for 1904.
[c] Losses for 1903.
[d] France reports for 1904 with exception of city of Lyon which is for 1901.

Sometime after these statistics were prepared the National Board of Fire Underwriters obtained permission from the State Department to send their own queries to the consular officers in Europe, with the result that figures showing the fire losses in six countries were obtained, some of them for a period of several years. These figures showed the surprisingly low per capita of 33 cents for the six countries, and are as follows:

Fire losses in six European countries.

[Statistics gathered by the National Board of Fire Underwriters.]

Country.	Years.	Fire loss, annual average.	Population 1901.	Loss per capita.
Austria	1898-1902	$7,601,389	26,150,507	$0.29
Denmark	1901	660,924	2,568,919	.26
France	1900-1904	11,609,275	38,595,500	.30
Germany	1902	27,655,600	56,367,178	.49
Italy	1901-1904	4,112,725	32,449,754	.12
Switzerland	1901-1905	999,364	3,325,023	.30

Or an average loss per capita of $0.33.

EUROPEAN AND AMERICAN LOSSES COMPARED.

Another comparison, which is perhaps even more interesting as illustrating America's needless waste and Europe's prudence, is given in the following table of per capita loss in cities of the United States and Europe, arranged in classes according to their populations:

Per capita fire losses in American and European cities, classified according to population.

[Statistics for the United States gathered by the Geological Survey, and for Europe by the Bureau of Manufactures.]

	Per capita loss, United States, 1907.	Per capita loss, Europe.
Cities over—		
300,000	$2.24	$0.65
100,000 to 300,000	2.14	.37
50,000 to 100,000	2.47	1.67
30,000 to 50,000	3.28	.72
10,000 to 30,000	2.37	.81
Under 10,000	3.47	....

FIRE LOSSES IN CITIES OF EUROPE AND AMERICA OF EQUAL SIZE.

Comparing American and European cities of the same size, and the following per capita losses are found:

Fire losses in American and European cities of the same size.

[Statistics gathered by U. S. Geological Survey and Bureau of Manufactures.]

European losses for 1904.				United States losses for 1907.			
	Population.	Fire loss.	Per capita.		Population.	Fire loss.	Per capita.
Paris, France	2,714,068	$1,266,282	$0.47	Chicago, Ill	2,049,185	$3,937,105	$1.92
Frankfort, Germany	324,500	99,492	.31	Cincinnati, Ohio	345,230	1,971,217	5.70
St. Petersburg, Russia	1,500,000	2,128,541	1.42	Philadelphia, Pa	1,441,735	2,093,522	1.45
Birmingham, England	550,000	226,506	.41	Baltimore, Md	553,669	916,603	1.66
Sheffield, England	426,686	75,989	.18	Cleveland, Ohio	460,000	515,194	1.12
Toulon, France	101,602	55,391	.55	Atlanta, Ga	104,984	225,237	2.15
Bremen, Germany	203,847	78,372	.38	St. Paul, Minn	204,000	522,447	2.56
Molenbeek, Belgium	63,678	106,150	1.67	Evansville, Ind	63,957	196,702	3.08
Laiken, Belgium	31,121	22,349	.72	Oshkosh, Wis	31,033	80,500	2.59
Etterbeck, Belgium	23,992	19,504	.81	Easton, Pa	25,238	32,073	1.27

CONFLAGRATIONS.

Since the year 1866 the conflagration losses in the United States have totaled the sum of $936,551,135, according to the tabulation made by the National Board of Fire Underwriters. By conflagration is meant all fire involving a loss of half a million dollars and over.

The conflagrations of 1907 cost the United States $18,475,000, according to the same authority.

The year 1908 promises to exceed the conflagration loss of the preceding year, one conflagration alone, that at Chelsea, Mass., on April 12 and 13, involving an insurance loss of $8,846,879, as reported by the underwriting companies to the Massachusetts insurance commissioner.

The notable conflagrations of the United States were those at Chicago, in 1871; Boston, 1872; Baltimore, 1904; and San Francisco on April 18, 1906. The earthquake and fire at San Francisco resulted in a total property loss of $350,000,000, exceeding in amount any previous similar disaster in the history of the world.

The fact that no other country suffers such enormous conflagration losses has led to a general investigation of the causes by fire underwriters, fire marshals, officials of States and municipalities, and students of economic conditions, and the conclusion has been that poor and defective construction of buildings and equipment are responsible. The investigation has further disclosed that an increase in the number and severity of conflagrations may be expected until there is a decided improvement in the methods of construction.

The danger of conflagration is present in every city and village of the United States, and with it the possibility of large loss of life. The most efficient fire department in the country is powerless when once a fire gets considerable headway in a locality where bad construction prevails.

The Ohio fire marshal, in his annual report for 1907, in urging new building codes for Cleveland and Cincinnati, the two largest cities of the State, says: "Either city may at any time suffer a conflagration costing $300,000,000."

The October, 1908, Quarterly of the National Fire Protective Association, on the subject of better buildings, says:

> The average American city is full of fire traps. Buildings of great area, without fire cut-offs, with large floor openings, with unprotected windows, and with very combustible contents are too numerous to prove the exception to any rule. These are conflagration breeders. Fire travels through these buildings rapidly and under certain conditions can get beyond even the best fire department, and sweeping through the unprotected windows of surrounding buildings will soon cause a conflagration.

LIVES LOST IN FIRES.

During the year 1907 fires caused the death of 1,449 persons and the injury of 5,654, according to the information gathered by the United States Geological Survey. These figures are incomplete and perhaps do not represent more than half the persons who were victims of fires. Many fire chiefs of large cities failed to report any deaths, because such were not properly included in their annual reports. The cause of this again is faulty construction in buildings—in many instances lack of appreciation on the part of cities of the responsibility to safeguard the lives of their citizens or ignorance of what is demanded to protect against fires.

The Iroquois fire in Chicago, December 30, 1903, in which 600 persons lost their lives, was a terrible object lesson in bad construction and equipment, yet this was not sufficient to stop these disasters. January 13, 1908, fire in an opera house at Boyertown, Pa., cost the lives of nearly 200 women and children. Two months later, March 4, 165 children were burned to death in a schoolhouse at Collinwood, Ohio. With proper construction of buildings none of these lives would have been lost.

SUMMARY.

The capital investment and the annual maintenance cost making up loss and expense on account of fire losses, fire protection, cost of waterworks chargeable to conflagration service, maintenance of fire departments and private fire-fighting devices are summarized in the following table.

Capital invested for fire protection and annual loss and expense on account of fire (United States, 1907.)

Annual loss and expense:		
Total fire loss		$215,084,709
Fire protection—		
Amount of fire-insurance premiums paid above amount of losses paid		[a] 145,604,362
Total annual expense of waterworks chargeable to fire service—		
Depreciation and taxes	4,603,731	
Interest charge	[b] 9,826,867	
Maintenance	8,465,487	
		28,856,235
Total annual expense of fire departments—		
Depreciation and taxes	4,603,731	
Interest charge	[c] 4,282,540	
Maintenance	40,054,574	
		48,940,845
Total annual private fire protection		18,000,000
Total annual loss and expense		456,486,151
Investment in construction and equipment:		
Total cost of waterworks (construction and equipment) chargeable to fire service—		
Source of water supply	$66,482,220	
Distributing system (2,016,927 tons of metal)	127,236,668	
Hydrants (350,152)	29,761,400	
Separate high-pressure fire service	22,191,388	
		[d] 245,671,676
Total cost of fire departments (construction and equipment)		107,063,524
Total cost (construction and equipment) of private fire extinguishers, automatic sprinklers, etc		50,000,000
Total investment in construction and equipment		402,735,200

A study of this table shows that 22 per cent of the total expenditure on behalf of public water supplies is due to additional supplies necessary for protection against fires of such magnitude as may be propagated beyond the building of origin. It will be incidentally noted that there are 2,000,000 tons of metal, having a value in excess of $127,000,000, and the metal in 350,000 hydrants, having a value of nearly $30,000,000, all of which is wasted on account of the need of preparation to fight fires of a kind which, because of the inflammable character of building construction in this country, would develop into conflagrations without adequate water service and fire departments.

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[a] The amount paid by insurance companies on account of fire loss was $114,164,469, and the amount received by them in premiums was $259,768,831.

[b] $245,671,676, cost of waterworks, chargeable to fire service, capitalized at 4 per cent interest, is equal to an annual charge of $9,826,867.

[c] $107,063,524, cost of fire departments, capitalized at 4 per cent interest, is equal to an annual charge of $4,282,540.

[d] This is 22 per cent of the total cost of water systems, domestic and fire service combined.

The annual cost of maintenance of fire departments in European cities is set forth in the following table, from which it is apparent that the average annual cost in European cities is 20 cents per capita. Compared with this, the average cost in cities in the United States having a corresponding population of 100,000 and over and an aggregate population closely approximating that of these European cities, shows a per capita cost of $1.53, or seven and one-half times the cost of public fire protection over and above that found necessary in Europe.

Annual cost maintenance of fire departments in European cities.

City.	Population.	Fire department maintenance.	Per capita.
Kiel and suburbs	171,000	179,002m. = $42,602	$0.25
Cologne and suburbs	458,037	509,609m. = 121,286	.26
Berlin	1,888,848	2,035,346m. = 484,412	.26
Breslau	422,738	465,571m. = 110,805	.26
London	6,580,616	254,045 £. = 1,238,409	.19
St. Petersburg	1,313,300	578,503 r. = 295,036	.22
Paris	2,714,068	2,925,334 f. = 564,589	.21
Stockholm	311,043	269,164K. = 72,135	.23
Budapest	723,322	281,544K. = 57,123	.08
Milan	491,400	431,253 l. = 83,231	.17
Total	15,074,432	3,069,688	[a] .20
Cities in United States having population of 100,000 and over	16,883,435	25,734,386	1.53

[a] Average.

It is reasonable to assume that at such time as building construction in the United States, through the materials used, building codes adopted, and the enforcement thereof, shall have reached a condition similar to that in Europe our annual costs for this one item alone may be reduced from more than $25,000,000 to $3,000,000, or to less than one-seventh of the present total.

It will be noted that the per capita cost in this country and in Europe which make up these total figures are nearly equally divided between the fire losses and the annual expense of fire protection, and that the ratio of these in the United States and in Europe is nearly the same.

NATIONAL VITALITY, ITS WASTES AND CONSERVATION.

By **Irving Fisher**,
Professor of Political Economy, Yale University.

ACKNOWLEDGMENTS.

The materials upon which this report is principally based were collected during the last ten years. They are far from complete, and I had expected to make use of them at my leisure for a series of special articles, but the opportunity which suddenly presented itself of utilizing them in the construction of this report was one which could not be resisted, despite the fact that the time available was only three months. In the endeavor to make the best use of this time I have been compelled in some cases to rely on secondary sources of information. The number of such cases has been greatly reduced, however, through the kindness of colleagues, friends, and correspondents who were appealed to for suggestions, criticisms, and supplementary material. I am greatly indebted to Prof. Lafayette B. Mendel, of the Sheffield Scientific School of Yale University, for helpful comments and detailed criticism of the whole report, and especially of those parts relative to the physiology of nutrition; to Prof. Yandell Henderson, for many helpful suggestions; to Prof. Henry W. Farnam, for suggestions regarding the topics of industrial conditions; to Prof. M. V. O'Shea, of the University of Wisconsin, for carefully revising the major part of the section on school hygiene; to Dr. Charles Wardell Stiles, Chief of the Division of Zoology, Hygienic Laboratory, United States Public Health and Marine-Hospital Service, for information on the extent and burden of the hook-worm disease; to Surg. Gen. Robert M. O'Reilly, of the United States Army, for statistics of army hygiene; to Dr. Prince A. Morrow, of New York City, and to Prof. C. R. Henderson, of the University of Chicago, for carefully prepared notes in regard to "the social evil."

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board of health; Prof. F. F. Wesbrook, dean of the Medical School of the University of Minnesota; Dr. Henry B. Baker, ex-secretary Michigan state board of health; Dr. William C. Woodward, health officer of the District of Columbia; Dr. George M. Kober, dean of Georgetown Medical College; Dr. Norman E. Ditman, of Columbia University; Dr. J. H. Kellogg, superintendent of the Battle Creek Sanitarium, and his assistants, Dr. J. T. Case and Dr. W. H. Riley; Dr. Richard C. Newton, of Montclair, N. J.; Dr. Luther H. Gulick, of New York City; Dr. W. G. Anderson, director Yale gymnasium; Dr. Charles H. Castle, of Cincinnati, Ohio; Dr. J. P. C. Foster, of New Haven; Prof. Russell H. Chittenden, director of the Sheffield Scientific School of Yale University; Leo F. Rettger, assistant professor of hygiene, Yale University; Dr. George M. Gould, of Ithaca, N. Y.; Dr. Helen C. Putnam, of Providence, R. I.; F. B. Sanborn, of Cambridge, Mass.; Hiram J. Messenger, actuary of the Travelers Insurance Company, Hartford; Mrs. Ellen H. Richards, of the Massachusetts Institute of Technology; Mrs. Frank P. Kinnicutt, of New York City; and William H. Tolman, of the Museum of Safety and Sanitation, New York City.

To the help received from these persons will be due in large measure whatever of value this report may have. I could not, single-handed, have done justice to even a portion of the subject. Except for a few statistical monographs and papers cited in it, I have contributed little original material. It has been my task to interpret material brought together from many sources. Despite all the aid received, I am aware that the report abounds in sins of omission. Great pains have been taken to avoid those of commission. Doubtful material has been eliminated so far as possible, and where exact figures were unobtainable, every effort has been made to see that the statements made should be cautious and conservative.

For aid in the difficult work of incorporating into the manuscript the numerous suggestions received, I am indebted to Profs. J. Pease Norton, William B. Bailey, Fred R. Fairchild, and Dr. L. W. Zartman, of the economic department of Yale University; and to Dr. M. M. Scarborough, of the Yale Medical School, and Dr. F. B. Standish, of New Haven. For criticisms on the form of presentation, I am indebted to Mr. Edwin Bjorkman, of New York City; to Mr. Michael Williams, of Oak Bluffs, Mass.; and to Mr. Herbert A. Smith, of the U. S. Forest Service.

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IRVING FISHER.

YALE UNIVERSITY, *November, 1908.*

SUGGESTIONS FOR READERS.

In order that this report may be read and used as widely as possible, it has been arranged with reference to five classes of readers:

1. The "Contents by sections," the index, and the page headings will facilitate the use of the report for reference purposes.
2. The "Abstract" is chiefly intended for those who have no time to read more.
3. The "Summary" is a somewhat fuller résumé.
4. The "Summary" is also designed to enable those who so desire to read some parts of the report more fully than others. To this end the "Summary" is arranged to correspond to the main report, chapter by chapter and section by section. The reader who, after reading any particular part of the "Summary," wishes to read the corresponding part of the main report has only to turn to the chapter or section having the same number.
5. Those who read the entire report will probably prefer to read the "Summary" or "Abstract" last.

ABSTRACT.

The problem of conserving natural resources is only one part of the larger problem of conserving national efficiency. The other part relates to the vitality of our population. The two parts are closely interwoven. Protection against mining accidents, forest fires, floods, or pollution of streams prevents not only loss of property, but loss of life. The prevention of disease, on the other hand, increases economic productivity.

So far as we can compare vital and physical assets as measured by earning power, the vital assets are three to five times the physical. The facts show that there is as great room for improvement in our vital resources as in our lands, waters, minerals, and forests. This improvement is possible in respect both to the length of life and to freedom from disease during life.

Contrary to common impression, there is no iron law of mortality. Recent statistics for India show that the average duration of life there is less than twenty-five years. In Sweden it is over fifty years, in Massachusetts forty-five years. The length of life is increasing wherever sanitary science and preventive medicine are applied. In India it is stationary. In Europe it has doubled in three and a half centuries. The rate of increase during the seventeenth and eighteenth centuries was about four years per century, during the first half of the nineteenth century about nine years per century, during the latter half of the nineteenth century about seventeen years per century, and in Germany, where medical and sanitary science has reached the highest development, about twenty-seven years per century. The only comparative statistics available in this country are for Massachusetts, where life is lengthening at the rate of about fourteen years per century, or half the rate in Germany.

There is no need, however, of waiting a century for this increase. It could be obtained within a generation. Three-fourths of tuberculosis, from which 150,000 Americans die annually, could be avoided. Eighteen experts in various diseases, as well as vital statisticians, have contributed data on the ratio of preventability of the ninety different causes of death into which mortality may be classified. From these data it is found that fifteen years at least could be at once added to the average human lifetime by applying the science of preventing disease. More than half of this additional life would come from the prevention of tuberculosis, typhoid, and five other diseases, the prevention of which could be accomplished by purer air, water, and milk. In Lawrence, Mass., after the installation of a pure-water supply, the death rate from typhoid was reduced by 80 per cent. For every death thus saved from typhoid, two or three deaths are saved from other diseases.

Judging from the English statistics of illness, we must conclude that at all times in the United States about 3,000,000 persons are seriously ill, of whom about 500,000 are consumptives. Fully half of this illness is preventable.

If we appraise each life lost at only $1,700 and each year's average earnings for adults at only $700, the economic gain to be obtained from preventing preventable disease, measured in dollars, exceeds one and a half billions. This gain, or the lengthening and strengthening of life which it measures, can be secured through medical investigation and practice, school and factory hygiene, restriction of labor of women and children, the education of the public in both public and private hygiene, and through improving the efficiency of our municipal, state, and national health service. Our National Government has now several bureaus exercising health functions, which only need to be concentrated under one department to become coordinated parts of a greater health service worthy of the nation.

SUMMARY.

SUMMARY OF PART I.—*Length of life versus mortality.*

SUMMARY OF CHAPTER I—THE LENGTH OF LIFE.

SECTION 1. *In different places.*—President Roosevelt has pointed out that the problem of conserving our natural resources is part of another and greater problem—that of national efficiency. This depends not only on physical environment, but on social environment, and most of all on human vitality. Modern hygiene is the reaction against the old fatalistic creed that deaths inevitably occur at a constant rate. The new motto is that of Pasteur: "It is within the power of man to rid himself of every parasitic disease."

It was once believed that human mortality followed an "inexorable law." Facts, however, show that mortality varies in different places and is decreasing as hygiene comes into use. The length of life in Sweden and Denmark is over fifty years; in the United States and England about forty-five; in India less than twenty-five.

SEC. 2. *At different times.*—In Europe, according to one authority, the length of life has increased in three hundred and fifty years from less than twenty to about forty years; in England, in less than half a century, it has increased about five years; in Prussia, in the last quarter of a century, over six years; in America it has also increased, although good life tables are lacking excepting for insurance experience. The tables for Massachusetts for 1893–1897 show an average duration of life in that State of forty-five years, as compared with forty in 1855, and thirty-five, an estimate of 1789, based, however, on doubtful returns.

SUMMARY OF CHAPTER II—THE MORTALITY RATE.

SECTION 1.—*Relation of longevity to mortality.*—As duration of life increases the death rate decreases. A death rate is the ratio of the number of deaths in a year to the population. Under normal conditions where the population is "stationary"—that is, neither increasing nor decreasing nor subject to immigration or emigration—the death rate and the duration of life are "reciprocals." In such a population, if the death rate is 20 per 1,000, the duration of life will be 1,000÷20=50 years.

This relation, however, is disturbed in most countries to-day, and especially in America, by immigration and emigration and by the birth rate being in excess of the death rate. Nevertheless, death rates, if compared under similar conditions, furnish a fairly good index of vitality. They vary in different places and at different times.

SEC. 2. *Mortality in various regions.*—In the registration area of the United States the death rate is 16.5 per 1,000; in France it is 20; in India 42. In different States of the United States it varies from 14 in Michigan to 18 in New York.

SEC. 3. *Urban and rural mortality.*—The death rate is higher in the city than in the country, and the larger the city the higher the death rate. In European countries among the cities with the highest death rate are Dublin (40) and Moscow (37); among the lowest, Frankfort on the Main (16) and The Hague (16).

SEC. 4. *Race and condition.*—The colored death rate greatly exceeds the white. The death rate among the poor exceeds that among the rich, being in Glasgow and Paris over twice as great.

SEC. 5. *Mortality historically.*—Death rates have been decreasing during several centuries. In London, where now the death rate is only 15, it was during the seventeenth and eighteenth centuries 40 to 50, and during 1680 to 1728, a period of pests, it rose as high as 80. Similar reduction has also been experienced in this country. In Habana the death rate after the American occupation fell from over 50 to about 20.

SEC. 6. *Adult and infant mortality.*—The greatest reduction has been effected among children, although the death rate is still undoubtedly high. Statistics show that during the last thirty years the death rate up to 50 years of age has decreased, but that beyond 50 it has remained almost stationary.

SEC. 7. *Particular diseases.*—The mortality from certain special diseases has greatly decreased. The tuberculosis death rate is now in England only one-third of what it was seventy years ago. The death rate from pneumonia now equals that of tuberculosis. Typhoid fever is decreasing. In Munich during 1856 the mortality was 291 per 100,000 of population. The city at that time contained many cesspools. After these were filled up the typhoid rate fell to 10 per 100,000 in 1887, making a reduction of 97 per cent. In Lawrence, Mass., after the public water was filtered in 1893 the typhoid-fever rate fell from 105 to 22. Doctor Kober has shown that death rates from typhoid fever are greatest in cities in which the rivers' waters are polluted, the average for these cities being 62, as compared with 18 for cities using unpolluted water of impounded and conserved streams. Doctor Rosenau concludes that any community having clean water and uninfected milk supply may be free from typhoid.

Smallpox has greatly decreased since vaccination has been employed. In Prussia the death rate per 100,000 from smallpox between 1846 and 1870 was 24. In 1874 vaccination was made compulsory, and the death rate for the years 1875–76 fell to 1.5. Similar figures can be given for other places. The present outcry against vaccination is based on misinformation and on the general reasoning that it is unnatural to introduce a poison into the blood. Statistics show clearly that vaccination decreases smallpox and lengthens life. Even though it were shown that the virus is injurious, it would be the lesser of two evils.

Yellow fever in Philadelphia in 1793 caused the death of one-tenth of the city's population within six and one-half weeks. In 1900 it was found that a species of mosquito transmits this disease. The result of this applied knowledge is that the disease has practically disappeared in America.

SUMMARY OF PART II.—*Breadth of life versus invalidity.*

SUMMARY OF CHAPTER III—PREVALENCE OF SERIOUS ILLNESS.

SECTION 1. *Loss of time.*—Life is shortened by death and narrowed by invalidity. The ideal life, with respect to health, would be free from illness and disability of every kind. To approximate such an ideal is the aim of hygiene. It is usually true that the healthier a life the longer it will last. Humboldt maintained that he had lived four working lives by retaining a working power double the average for double the average number of years. According to Farr, for every death there is an average severe sickness of two years, or for each death per year there are two persons sick throughout the year. This would mean in the United States that, as there are about 1,500,000 annual deaths, there will always be about 3,000,000 persons on the sick list, which is equivalent to about thirteen days per capita.

SEC. 2. *Particular diseases.*—There are constantly ill in the United States of tuberculosis about 500,000 persons, of whom about one-half are totally incapacitated, while the remainder are half incapacitated. The causes of various diseases are closely interwoven. Professor Sedgwick tells us that "Hazen's theorem" shows for every death from typhoid fever avoided by the purification of a polluted water supply two or three deaths are avoided from other causes. Hook-worm disease in the South is a chief cause of incapacitation, especially among the poor whites. For this reason the hook worm has been nicknamed the "germ of laziness." It is believed that a sufferer from hook-worm disease is incapacitated from one-fourth to one-half of the time.

The number of syphilitics in the United States has been estimated at 2,000,000, though from the nature of the case this figure is chiefly conjecture. The social diseases, syphilis and gonorrhea, are responsible for the existence of a large proportion of defectives of various kinds which fill our institutions. Among the troops in the Philippines the venereal morbidity, during the year 1904, was 297 per 1,000, largely exceeding the morbidity from malarial fevers and diarrhea, as 22 out of every 1,000 soldiers were constantly ineffective from venereal disease—four times as many as from any other disease. The statistics outside of army and navy service are impracticable, but there is some reason to believe that they might show an even larger morbidity. The social diseases, which certainly are preventable, are one of the gravest of the menaces to national efficiency.

American railways in 1907-8 killed nearly 11,800 and injured nearly 111,000 persons. The deaths and disablements from accidents in industry, although less carefully recorded, also represent a great and needless impairment of efficiency.

SUMMARY OF CHAPTER IV—PREVALENCE OF MINOR AILMENTS.

SECTION 1. *Importance of minor ailments.*—Minor ailments are far more common than most persons realize. They are chiefly functional disorders, such as of the stomach, heart, nerves, liver, kidney, etc. These deserve more attention than they have hitherto received, because they are the gateway to more serious troubles. For instance, those who neglect colds, or what seem to be colds, will be far more likely to become victims of tuberculosis or pneumonia. No statistics of the prevalence of minor ailments exist. Physicians, whose experience gives them good opportunity to judge, place the time lost annually for each person from minor ailments at three or more days a year.

SEC. 2. *Preventability of minor ailments.*—Practically all minor ailments can be avoided by proper hygiene, public and private. Neurasthenia, so common in America, is one of the most serious and insidious introductions to grave disorders, and is usually due to needless worry or failure to have adequate recreation.

SUMMARY OF CHAPTER V—PREVALENCE OF UNDUE FATIGUE.

SECTION 1. *Strength, endurance, and fatigue.*—Strength is measured by the force a muscle can exert once; endurance by the number of times it can repeat an exertion requiring a specified part of the strength. Fatigue is a chemical effect, due to "fatigue poisons." Far greater differences exist between different persons in respect to endurance than in respect to strength. Some "well" people become tired by a short walk, while others withstand hours of walking, running, or climbing.

SEC. 2. *Alcohol and fatigue.*—The "Committee of Fifty" found that alcohol gives no persistent increase of muscular power. It is well understood by all who control large bodies of men engaged in physical labor that alcohol and effective work are incompatible. Rivers, writing on the influence of alcohol on fatigue, found that when workmen were provided with a moderate amount of wine it resulted in a considerable diminution of their capacity for work.

SEC. 3. *Tobacco and fatigue.*—Athletes recognize that smoking interferes with one's "wind" or "staying power." "Inhaling" tobacco smoke brings carbon-monoxide directly into the blood stream. It is found that smoking increases blood pressure, which fact possibly partly explains the reduction in endurance.

SEC. 4. *Diet and fatigue.*—When excessive amounts of the protein element in food (exemplified in white of egg or the lean part of meat) are taken, they putrefy in the large intestine, producing "auto-intoxication." For this and other reasons, there is a present tendency among physiologists to advise a reduction in the use of such foods from the amounts customary in many countries, and especially in the United States. Auto-intoxication induces fatigue. The endurance of those using high protein and of those using low protein shows in general, although with some exceptions, that the former have less endurance than the latter. Whether the latter are vegetarian or not does not seem to matter. Experiments show that thorough mastication leads instinctively to a reduction in protein.

SEC. 5. *Exertion and fatigue.*—Oxygen, whether taken naturally or artificially, increases the capacity for exertion. A judicious amount of exercise is perhaps the chief factor in producing the highest state of muscular efficiency. Physical training, comprising exercise and other hygienic measures, will probably make the capacity to withstand great exertion three or four times that possessed by most persons.

SEC. 6. *The working day.*—The present working day, from a physiological standpoint, is too long, and keeps the majority of men and women in a continual state of overfatigue. It starts a vicious circle, leading to the craving of means for deadening fatigue, thus inducing drunkenness and other excesses. Experiments in reducing the working day show a great improvement in the physical efficiency of laborers, and in many cases results in even increasing their output sufficiently to compensate the employer for the shorter day. Several examples of such a result exist, but the real justification for a shorter work day is found in the interest of the race, not the employer. One company, which keeps its factory going night and day, found, on changing from two shifts of twelve hours each to three shifts of eight hours each, that the efficiency of the men gradually increased, and the days lost per man by illness fell from seven and one-half to five and one-half per year. Public safety requires, in order to avoid railway collisions and other accidents, the prevention of long hours, lack of sleep, and undue fatigue in workmen.

SEC. 7. *The importance of preventing undue fatigue.*—The economic waste from undue fatigue is probably much greater than the waste from serious illness. This is because the number of fatigued persons is great enough to more than outweigh the fact that the incapacitation from fatigue is relatively small. Moreover, the relatively slight impairment of efficiency due to overfatigue leads to greater impairment from serious illness. A typical succession of events is, first, fatigue, then "colds," then tuberculosis, then death. The prevention of undue fatigue means the arrest at the start of this accelerating chain of calamities.

SUMMARY OF PART III.—*Methods of conserving life.*

SUMMARY OF CHAPTER VI—CONSERVATION THROUGH HEREDITY.

SECTION 1. *Heredity and environment.*—A wise and farsighted economy will lead the nation to conserve its vital resources by every possible method. These resources depend on two primary conditions, heredity and hygiene, or conditions preceding birth and conditions during life. In other words, vitality is partly inherited and partly acquired. A sound physical and mental inheritance is a greater asset than the inheritance of extraneous advantages like wealth. Even in the Old World a degenerate nobility in the end receives less respect than a virile middle class. The effort to improve vitality reaches its highest point in a nation when its health ideals affect marriage.

SEC. 2. *Eugenics.*—Galton, Pearson, and others are attempting to found the new science of "eugenics," by which is not meant any scheme of general governmental interference with marriage, but the gradual establishment in public opinion of fundamental standards. Just as to-day the marriage of brother and sister is unthinkable, Galton suggests that the time may come when marriage which obviously promotes degeneration will be equally tabooed. The result would be, not to make marriage more artificial, but less. Health, beauty, and vitality are much more natural objects of youthful admiration than titles or wealth, which now exercise, for the most part, a baneful influence on marriage. To lessen the esteem for those false attractions and increase that for natural attractions will tend not only to increase the number of healthy marriages, but to give greater importance to natural and normal love. The effect will be felt both in bringing about a larger proportion of marriages among the healthy and a smaller proportion among the unhealthy. It will also lead to a partial segregation by which the healthy will to a large extent marry among themselves, and thus leave the unhealthy either unmarried or compelled to make alliances in their own class. The result will be, in the struggle for race supremacy, that the healthy, thus separated off from the relatively unfit, will have a distinct advantage both in the number of offspring and in their vitality.

SEC. 3. *Eugenics and law.*—The only government influences which have been seriously suggested by eugenists are two: First, the offering of prizes or bounties to couples who conform to certain standards, in the same way as the French Government has encouraged the increase of its population by offering inducements to couples of the poorer class who raise seven or more children; second, to prevent marriage alliances among criminals, paupers, and the feebleminded. Some laws on these subjects already exist in Connecticut, Michigan, and especially Indiana, where there is a prohibition of marriage of all persons suffering from transmissible diseases. It is also now provided in Indiana that confirmed criminals, imbeciles, and rapists, when it is deemed advisable by experts, shall be unsexed. What such laws might accomplish may be judged from the history of two criminal families, the "Jukes" and the "Tribe of Ishmael." Out of 1,200 descendants from the founder of the "Jukes" through seventy-five years, 310 were professional paupers, who spent in all two thousand three hundred years in poorhouses, 50 were prostitutes, 7 murderers, 60 habitual thieves, and 130 common criminals. The loss of potential usefulness, cost of prosecutions, expense of maintenance of jails, etc., Dugdale estimated to be $1,300,000 in seventy-five years, or over $1,000 for each member of the family. All these unfortunate results could have been avoided had the original criminals in this family been sterilized under a law like that of Indiana.

We have the more agreeable record of excellent human qualities inherited through successive generations in the Darwin, Hohenzollern, and other families.

SUMMARY OF CHAPTER VII—CONSERVATION THROUGH PUBLIC HYGIENE.

SECTION 1. *Municipal hygiene.*—The benefits of improved heredity can be enjoyed only by future generations. But we of the present day may conserve our vital resources through hygiene, practiced in one or all of three ways—public, semipublic, and personal hygiene. The first refers to governmental regulation of health, the second to the professional or institutional care of health, and the third to the private life of the individual and the family. Every city now has its health board, yet few citizens realize that the protection rendered by these boards is more important than the protection by the police or fire departments. Much as is done by these boards, there is enormous room for improvement, both in making regulations and in enforcing them by the aid of a more enlightened public opinion. The abatements of the nuisance and menace from spitting and from vitiation by smoke are cases in point. Pure air is one of the primary necessaries of life, but only a small fraction of our countrymen actually enjoy this boon. To this end proper drainage and garbage removal and clean streets are needed. The transmission of disease by insects, flies, and vermin needs to be checked. A constant cause of mortality, among infants especially, is an impure milk supply. The same danger exists in other dairy products, cream, butter, cheese, and ice cream. In Washington, owing apparently to the enactment of a law in 1895 regulating the sale of milk, the death rate from diarrhea and inflammation of the bowels among children under 2 years of age was reduced from 160 or 170 to 135, then 109, 104, and in 1906 to 97. Similar reports come from many other cities in this country and abroad.

SEC. 2. *State hygiene.*—The regulation of the labor of women and children is usually a state matter. It has been suggested by Doctor Stiles that every woman should be allowed once a month to leave a factory without being asked questions or losing wages. The employment of mothers before and after childbirth should be prohibited, as it is now in a number of European countries. This single reform would help greatly to conserve the vitality of the next generation. Child labor in the South is in many cases the lesser of two evils, the other being exposure to the hook-worm disease on polluted farms. In these cases, the abolition of child labor should be preceded by the abolition of hook-worm disease. Hours of labor have been steadily decreasing, and should be decreased further. Accidents are unnecessarily frequent on our American railroads, as well as in industrial establishments. Statistics do not exist for the latter. Special trades have special dangers. Among such trades are those using lead and other dangerous poisonous chemicals, as well as the dust-producing trades which tend to pulmonary troubles. The dark room tenements are a common means in our large cities of depleting national vitality.

SEC. 3. *Federal hygiene.*—This includes quarantine, the inspection of immigrants and exclusion of those with infectious diseases, administration of government hospitals, of pure-food laws and meat inspection, and cooperation with state boards of health in fighting yellow fever, bubonic plague, etc. Federal power needs extension, however. Our interstate railroads should be improved in respect to the sanitation of sleeping cars, smoking cars, etc.

The movement to secure a more intelligent national organization of health is now being pushed by the President, President-Elect, and Members of Congress, and has found expression in the recent platforms of both political parties. What is needed is that the Federal Government should make the national capital a model of sanitation, should provide for more investigation in health matters and the dissemination of information on the prevention of tuberculosis, etc., should cooperate further with state and municipal authorities, and should check the pollution of interstate streams and prevent the transmission of disease-bearing meats or other food from one State to another. Lastly, it should secure, through whatever constitutional means exist, some method of collecting statistical information as to our national mortality and morbidity. Our shortcomings in this respect are now a national disgrace. There is no accurate record of births in any part of the United States, and that of deaths includes less than half our population. As a statistician has said of one of the States, "It buries its dead people with no more ceremony than it buries its dead dogs." Obviously, no intelligent control of epidemics and other diseases can be made unless the facts in regard to those diseases are known; in other words, unless there exist mortality and morbidity statistics of real value.

SUMMARY OF CHAPTER VIII—CONSERVATION THROUGH SEMIPUBLIC HYGIENE.

SECTION 1. *Medical research and instruction.*—Semipublic hygiene comprises that relating to institutions and the medical profession. The hygiene of the future must depend more on discoveries in preventive medicine than on any other single factor, and institutions such as the Pasteur Institute, the Rockefeller and the Carnegie institutes, and the research laboratories of the Government and universities offer the most promising means of increasing this most useful and practical of all human knowledge. The knowledge is dispensed through medical schools in the training of physicians. These schools are improving so as to introduce more of hygiene and preventive medicine. We are still far, however, from having facilities for training public health officers, or giving them such a degree as D. P. H. (diploma of public health), as is given in England.

SEC. 2. *The medical profession.*—Antiseptic surgery has in the last century been the greatest triumph of the medical profession, and has given it a greater prestige than ever before. It has greatly reduced the mortality from operations, and is illustrated by the figures in army operations. The mortality of the wounded in the Crimean war among English troops was 15 per cent. The mortality in the Transvaal war, 1900–1901, was less than 6 per cent.

In the practice of medicine, the tendency is progressively to give up the use of violent drugs and to depend more on hygiene. Through the modern fight against tuberculosis, physicians have come to prescribe fresh air in their practice generally. They are now turning in like manner to exploit the resources of diet, exercise, bathing, and mental hygiene.

There is danger that these new fields will be preempted by quacks. Many quacks to-day, far from using patent medicines, oppose the use of any drugs whatever. In order that modern hygiene shall be applied by trained physicians, it is necessary that they provide more facilities in this direction. The leaders of the profession are making every effort to raise all members of their profession to their own high standard. This standard not only aims to prevent malpractice and unethical operations, but to set an example to the people in public service and in personal hygienic living.

SEC. 3. *Institutional hygiene.*—Hospitals have done much to prevent disease by segregating infectious cases. Institutions for the deaf and blind and other defectives have led to a better utilization of their powers. Institutional care of the insane has done much, too, but can do more. Mental hygiene as a whole needs to be more carefully studied and taught in all its relations—heredity, alcohol, syphilis, and environment.

The modern sanitarium has become a useful institution for prevention of serious illness, as distinct from the hospital, of which the function has been to cure. Department stores, hotels, and other commercial institutions are installing ventilating and other hygienic apparatus. The churches are also taking part in the health movement, especially the Emmanuel Church in Boston.

SEC. 4. *School hygiene.*—The hygiene of school children is especially important because of its application to human life in its early stages. There is a world-wide movement, led by Switzerland and some other countries of Europe, to obtain and apply knowledge of how to educate the mind without weakening the body. As it is, school children are especially exposed to contagious diseases, which under present conditions often sweep through a whole school before the local health board even hears of it. Quite as serious, if not more so, is the protecting of school children from imperfect seating, lighting, ventilation, and sanitation.

Backward children, with defects of eye, ear, nose, or throat, are numerous, but experiments have shown that the majority could be improved both in intellect and in morals.

In respect to school hygiene, it is not so much lack of knowledge as lack of application of knowledge which is at fault. In order to find and then correct defects of eyes, ears, teeth, etc., and properly apply our knowledge, medical inspection is necessary. Such inspections as have been made disclose an astonishing amount of ill health, the percentage of morbidity being from 20 to 60 per cent. The committee on physical welfare of school children in New

York found that 66 per cent needed medical or surgical attention or better nourishment; 40 per cent needed dental care; 38 per cent had enlarged glands of the neck; 31 per cent had defective hearing; 18 per cent had enlarged tonsils.

Eye strain is a particular evil of civilization, and makes its first appearance in school when the scholar tries to accommodate the eye to the short range which reading requires, but for which the eye mechanism is not well adapted by nature. The evil effects of eye strain are not confined to that organ, but extend to the whole nervous system, and indirectly to the whole organism. Doctor Gould, who has made a special study of this subject, goes so far as to maintain that "eye strain is the chief source of the functional diseases of our citizens."

At present medical inspection is the exception rather than the rule. Only 70 cities in the United States outside of Massachusetts, and 32 cities and 321 towns in Massachusetts, have systems more or less complete. New York employs 150 physicians, who visit each public school once a day to examine children set aside for that purpose by the teacher. In Providence a fresh-air school for children suffering from tuberculosis has been established. The cost of the school per capita is about 50 per cent more than the ordinary schools, but the results justify the expenditure.

Our scholars are being seriously injured by nervous overstrain. Probably this is not because too much work is being required, but because the performance of this work is not accomplished economically. Some experiments seem to indicate that children could accomplish as much intellectually with far less dissipation of nervous energy if they were in the schoolroom about half of the time now spent there. High pressure and long hours are bad economy in schools as in factories.

Playgrounds conserve child vitality and are far superior to formal gymnastics. They provide physical training which accords with child instincts, and keep the child out of mischief and often out of jail. Here, as elsewhere, the suppression by civilized and urban life of the instinct for play and amusement is responsible for much of what we call "crime" and "depravity." In school children should not only be surrounded by hygienic environment, but should be taught the value of hygiene. The suggestion of an annual "health day" or "health week" may prove a fruitful one for this purpose.

SEC. 5. *Voluntary and business organizations.*—Societies to prevent the spread of tuberculosis, social diseases, insanity, etc., or to advocate labor or health legislation (state and national), are now numerous and active. It is being found that philanthropy and profit are not always antagonistic. Labor organizations are connecting the health movement with the eight-hour movement. Farsighted employers are providing social secretaries to watch over the health, comfort, and happiness of their employees, and are often eager for practical suggestions in these matters.

Corporations that have installed apparatus for ventilation and sanitation, even sometimes for the benefit of their machinery rather than their employees, have in known instances gotten back the cost in lessened illness and greater efficiency of work.

An interesting experiment near Paris was that of a mill employing 44 men and 75 women and children. Largely through the services, instruction, and suggestions of a medical officer there was not a single death in three years.

The temperance reform has to-day a powerful impulse in the demands by employers for more efficient labor and by the public for greater safety in travel. Locomotive engineers, conductors, and ship captains who drink can not get employment.

Life-insurance companies may possibly in the future realize their opportunity to make financial gains by participation in the health movement.

Finally, one of the greatest potential agencies for bringing about health reform is the public press. It is already interested and active in the movement, although the good it does is often undone by inserting quack advertising. This not only does direct harm, but often ties the hands of the editor, preventing him from expressing any disapproval of nostrums, however injurious or immoral.

SUMMARY OF CHAPTER IX—CONSERVATION THROUGH PERSONAL HYGIENE.

SECTION 1. *Its importance.*—Personal hygiene is not only of direct importance to the individual, but furnishes the public opinion from which, and from which alone, sound public and semipublic hygiene can spring. Public hygiene will be ineffective unless supported by personal hygiene. The milk and water supply of a city may be ideal as supplied at a dwelling, but may be carelessly contaminated there. Observation shows that many of the world's most vital men and women have practiced hygiene and often thereby turned weak constitutions into strong ones. Cornaro, the Venetian nobleman, about to die at 37, adopted the "temperate life," taking especial care not to overeat. He lived to be nearly, or quite, 100.

SEC. 2. *Branches of personal hygiene.*—Personal hygiene comprises hygiene of environment (air, soil, dwellings, clothing), hygiene of nutrition, and hygiene of activity. The ideal conditions of health require purity in air, purity and proper use of food, and a proper balance between mental and physical activity, rest, and sleep. The present world-wide interest in personal hygiene and physical education is not due to any startling discoveries, but to the rediscovery of the importance of truths long insisted upon by the medical profession.

SEC. 3. *The hygiene of environment.*—The prime factor in environment is the atmosphere. Originally man was doubtless an outdoor animal. Civilization has brought him an indoor environment, and with it tuberculosis. Experiments in hospitals have shown that the agitation of the air by dry sweeping greatly increases bacteria. Air in a confined room may be contaminated by chemicals contained in wall paper, plaster, or mortar. The one place in which the individual has most control over his air supply is the bedroom. The fashion now of sleeping with wide-open windows, or even out-of-doors, is certain to improve American vitality. The windows of living and work rooms also may be open even in winter if a window board is used to deflect the air upward and prevent a cold stratum forming on the floor. The outdoor life or the abundant use of fresh air is an almost certain preventive of colds. This fact was commented upon by Franklin over a century ago, and has been rediscovered many times since, especially in the experience of army troops. The evils of bad air are not confined to its chemical content. A room is sometimes "close" simply because it is hot or overmoist or devoid of any air current.

The effect of air on the skin and of radiation of heat from the body is important. Consequently, a proper use of air involves a proper use of clothing, which needs to be both porous and light.

Closely connected with air hygiene is the hygiene of light. "Where sun and air enter seldom the physician enters often." The lighting of dwellings and schoolrooms is especially important with reference to the eyes. This is true also of even the color and texture of the printed page we read. Probably one-fourth of all educated people in America suffer from disturbances due more or less to eye strain and its numerous indirect effects.

SEC. 4. *The hygiene of nutrition.*—The scientific study of diet has only just begun, and few authoritative results can yet be stated. That diet has a distinct relation to endurance has been rendered probable by many investigations, which seem to show in particular that avoidance of overeating, and especially of excess in protein, and thorough mastication are wholesome rules. In the choice of foods the individual must be given a wide latitude. His own instinct, restored and educated by avoiding food-bolting which blunts it, will probably be a truer guide than the wisest of physiologists. Diseased foods, such as oysters polluted with sewage, may transmit typhoid and other maladies.

SEC. 5. *Drug habits.*—Poisons, whether taken into the body or produced within, are injurious. The commonest form of intoxication is alcoholic. Its evils are becoming more apparent than ever before. As Metchnikoff says, it lowers the resistance of the white corpuscles, which are the natural defenders of the body. It predisposes to tuberculosis and numerous other diseases. The findings of the "Committee of Fifty" for the investigation of the liquor problem are important evidence of the evils of the use of alcohol, and these have not received the attention which they deserve. Absinthe in France is being recognized now as a distinct menace to the nation, and in Germany there is a tendency toward a lessened use of alcohol in all its forms. But the movement against the abuse of alcohol has reached its highest point in America.

The evils of tobacco are less and are less appreciated. Its stunting effects on the growing child are especially harmful.

SEC. 6. *Activity hygiene.*—It is an encouraging sign of the times that baths are coming more into vogue, both through the private bath tub for the wealthy and the public baths for the poor. During the last generation the importance of exercise has come to be acknowledged, due largely to the growth of modern athletics. The athletic ideal of the Greeks was, however, higher than that which now prevails in this country. Overexertion, physical and mental, is one of the chief American faults. The danger signal of fatigue is seldom observed, and the instinct for recreation and amusement is often stifled.

SEC. 7. *Sex hygiene.*—Undue reticence on this subject is responsible for the general ignorance as to the extent to which the abuse of the sex relation is injuring this and every nation, physically, mentally, and morally. Syphilis poisons the blood and affects all parts of the body. It makes the individual a "bad risk" for life insurance companies for several years, and is likely to be transmitted to others through a kiss or through the use of a common towel, while the danger of transmitting from husband to wife, or vice versa, continues for many years. Syphilis is one of the few really hereditary diseases, and the saddest of all facts connected with it is that the guilty parent may escape and the innocent children suffer. Gonorrhœa, while usually cured without apparent impairment of health, destroys fertility, and for years after it has apparently ceased may be rearoused. It is responsible for a large number of the cases of infantile blindness and for a larger percentage of many of the serious troubles of women. The social diseases, while seldom assigned as a cause of death, are known to predispose to other diseases and greatly to shorten life.

SEC. 8. *Personal hygiene in general.*—The cumulative effect of hygiene, or of lack of hygiene, needs emphasis. Breathing, eating, working, and sleeping are matters of daily habit. If they are wrong, the evil, however slight, being repeated every day for many years, produces cumulative effects more subtle, but often more powerful, than the effects of sudden infection or accident.

SUMMARY OF CHAPTER X—ARE HYGIENIC MEASURES EUGENIC?

SECTION 1. *The prolongation of weak lives.*—The question has been raised whether reduction in infant and child mortality will not weaken rather than strengthen the race by interfering with natural selection and favoring the survival of the unfit. It is pointed out that the mortality at later ages of life has not decreased, as has that in the earlier ages. There is probably, however, a sufficient explanation of this in the fact that the improvement in hygienic living has not as yet affected adults as much as children. Parents are quick to apply for the benefit of their children new methods of preventing disease, such as sterilizing milk, but do not take the same precautions for themselves. The hurry and stress of modern life has in fact tended to produce in some respects more unhygienic habits among adults than prevailed under the simpler conditions of a generation ago.

SEC. 2. *Children's diseases impair both fit and unfit.*—It must be borne in mind also that the same children's diseases and other causes which tend to kill the unfit child also tend to injure the proper development of the fit. Consequently a lessening of children's diseases will have the effect of not only prolonging weak lives, but also of prolonging and developing the strong. Statistics, so far as available, appear to show that where infant mortality is the highest, mortality at all ages is high.

SEC. 3. *Fitness is relative to environment.*—What is sometimes called degeneration does not deserve that name. A lessening of physical strength, for instance, can not be called degeneration if conditions under civilization do not require the same physical strength as our barbarian ancestors needed. It is adaptation to existing conditions which measures fitness.

Whatever danger of degeneration there may be from the care of the insane and defective classes can be avoided if the health ideals of the nation are strong and broad enough to meet the situation, for with these high health ideals will come a demand which will prevent the perpetuation of the unfit and through the mere force of public opinion lead in general to healthier marriages.

SUMMARY OF PART IV.—*Results of conserving life.*

SUMMARY OF CHAPTER XI—PROLONGATION OF LIFE.

SECTION 1. *Life is lengthening.*—So far as we can judge from statistics of the average duration of life, it has been on the increase for three hundred and fifty years, and is now increasing more rapidly than ever before. During the seventeenth and eighteenth centuries the increase was at the rate of about four years per century; during the first three-quarters of the nineteenth century the rate was about nine years. At present in Massachusetts life is lengthening at the rate of about fourteen years per century; in Europe about seventeen; and in Prussia, the land of medical discovery and its application, twenty-seven. In India, where medical progress is practically unknown, the life span is short (twenty-five) and remains stationary.

SEC. 2. *Table showing further practicable prolongation.*—It is possible to estimate the effect on the length of life of the partial elimination of various diseases. Using the statistics, experience, and estimate of 18 physicians as to the preventability of each of the list of 90 causes of death, we find that the length of life could easily be increased from forty-five to sixty, an increase of one-third, or fifteen years. This would result in a permanent reduction in death rate of about 25 per cent. The principal reductions would be from infantile diarrhea and enteritis, over 60 per cent of which could be prevented, with the result of an addition to the average length of life of 2.32 years. Bronchopneumonia, also an infant disease, could be prevented to the extent of 50 per cent, whereby life would be lengthened by 0.60 year. Meningitis, which is usually fatal at the age of two, could be prevented by at least 70 per cent, and this prevention would lengthen the average life by 0.60 year. Eighty-five per cent of death by typhoid fever is unnecessary, and if avoided would lengthen life at least 0.65 year. It would be feasible to prevent at least 75 per cent of cases of tuberculosis of the lungs, and thereby to lengthen life by about two years. If the deaths from violence were reduced only 35 per cent, human life would be increased by 0.86 year. The prevention of 45 per cent of cases of pneumonia would lengthen life by 0.94 year. These seven diseases alone could easily be reduced by these amounts so as to lengthen life by eight years. This could be done simply through insistence by the public on pure milk, pure water, pure air, and reasonable protection from accidents.

SEC. 3. *Diagram showing effect of prolongation at different ages.*—If we take the diagram representing the life table of Massachusetts for 1893–1897, we may use it as the basis for constructing an ideal curve to show the effect of prevention if applied according to the ratios of prevention given in the preceding table. The results agree substantially with those found in the table and show that about thirteen or more years could easily be added to the average duration of life. The diagram also shows the extent to which the additional life would fall in different ages. The per cent of life which would fall to the ages between 17½ and 60, taken as the working period, would remain the same, namely, about 55 per cent.

SEC. 4. *Fifteen years a safe minimum estimate of prolongation possible.*—The estimate of fifteen years is a minimum because, first, it takes no account of future medical discoveries, such as a method of curing or preventing cancer and of postponing old age, as would Metchnikoff; second, it takes little account of the cumulative influence of hygiene. The full benefit of hygiene can not be felt until it is practiced throughout life, and not at the approach of specific danger. Most so-called "causes" of death are merely the last straws which break the camel's back. When a pure water supply prevents deaths from typhoid fever, it prevents two or three times as many deaths from other causes. Third, it takes no account of the racial effects of new health ideals leading, in a general way, as they must, to healthier marriages.

SEC. 5. *Need of lengthening human life.*—With increase of knowledge the period of education or preparation for life must constantly increase. This fact creates a need for a longer life, with the later periods of life increased in proportion. The result of such a prolongation will be not the keeping alive of invalids, but the creation of a population containing a large number of vigorous old men. Metchnikoff says, "The old man will no longer be subject to loss of memory or to intellectual weakness; he will be able to apply his great experience to the most complicated and most delicate parts of the social life."

SEC. 6. *The normal lifetime.*—It is usually recognized that human life is abnormally short, but no exact determination has ever been made of what constitutes a normal lifetime. Flourens maintains that a mammal lives five times the length of its growing period, which would mean, since the growing period for man does not cease until about 30, a normal human lifetime of one hundred and fifty years. Another method of estimating normal life is to reckon the length of normal life as the time when old age now sets in, 83 years. But clearly, if Metchnikoff is right in thinking that old age itself is abnormal, the normal lifetime must exceed 83. Many remarkable cases of longevity are on record, but most cases of reputed centenarians are not authenticated. Drakenburg's record was authentic, and he lived to be 146. Mrs. Wood, of

Portland, Oreg., recently died at 120. To what extent these exceptional cases could be made common can not, as yet, be known.

SUMMARY OF CHAPTER XII—THE MONEY VALUE OF INCREASED VITALITY.

SECTION 1. *Money appraisal of preventable wastes.*—Doctor Farr has estimated the net economic value of an English agricultural laborer at various times of life by discounting his chance of future earnings after subtracting the cost of maintenance. On the basis of this table we may construct a rough estimate of the worth of an average American life at various ages, assuming that only three-fourths of those of working age are actually earners of money or housekeepers. It gradually rises from a value of $90 in the first year to $4,200 at the age of 30, and then declines until it becomes negative for the higher ages. This estimate assumes $700 per year as the average earnings in middle life. This is largely conjecture, but is regarded as a very safe estimate. Applying this table to the existing population at various ages in the United States, we find that the average value of a person now living in the United States is $2,900, and the average value of the lives now sacrificed by preventable deaths is $1,700. The latter is smaller than the former because the age of the dying is greater than the age of the living. Applying the $2,900 to the population of eighty-five and a half millions, we find that our population may be valued as assets at more than $250,000,000,000; and since the number of preventable deaths is estimated at 630,000, the annual waste from preventable deaths is 630,000 times $1,700, or about $1,000,000,000. This represents the annual preventable loss of potential earnings.

We saw in Chapter III that there are always 3,000,000 persons in the United States on the sick list, of whom about 1,000,000 are in the working period of life and about three-quarters are actually workers and must lose at least $700, which makes the aggregate loss from illness more than $500,000,000. Adding to this another $500,000,000 as the expense of medicines, medical attendance, special foods, etc., we find the total cost of illness to be about $1,000,000,000 per year, of which it is assumed that at least one-half is preventable. Adding the preventable loss from death, $1,000,000,000, to the preventable loss from illness, $500,000,000, we find one and a half billions as the very lowest at which we can estimate the preventable loss from disease and death in this country. The true figures from the statistics available may well amount to several times this figure, but when statistics are based partially on conjecture, they need to be stated with special caution.

SEC. 2. *The cost of conservation.*—In Huddersfield the annual deaths of infants for ten years had been 310. By systematic education of mothers, the number in 1907 was reduced to 212. The cost of saving these 98 lives was about $2,000, or about $20 each. Gen. Leonard Wood declared that the discovery of the means of preventing yellow fever saves annually more lives than were lost in the Cuban war. The hook-worm disease in the South impairs the earning power of its workmen by 25 or 50 per cent. To restore this earning power costs, by curing this disease, on an average, less than $1 for each case. These and other examples show that the return on investments in health are often several thousand per cent per annum. Probably no such unexploited opportunity for rich returns exists in any other field of investment. An actuary suggests that if insurance companies should combine to contribute $200,000 a year for the purpose of improving the public health, the cost would be one-eighth of 1 per cent of the premiums, and it would be reasonable to expect a decrease in death claims of much more than 1 per cent. Even this 1 per cent would make a profit of more than seven times the expense.

SUMMARY OF CHAPTER XIII—THE GENERAL VALUE OF INCREASED VITALITY.

SECTION 1.—*Disease, poverty, and crime.*—Money estimates of waste of life are necessarily imperfect and sometimes misleading. The real wastes can only be expressed in terms of human misery. Poverty and disease are twin evils and each plays into the hands of the other. From each springs vice and crime. Again, whatever diminishes poverty tends to improve health, and vice versa.

SEC. 2. *Conservation of natural resources.*—The conservation of our natural resources—land, raw materials, forests, and water—will provide the food, clothing, shelter, and other means of maintaining healthy life, while the conservation of health likewise tends in many ways to conserve and increase wealth. The more vigorous and long-lived the race, the better utilization it will make of its natural resources. This will be true for two reasons in particular: First, the greater inventiveness or resourcefulness of vigorous minds in vigorous bodies. Civilization consists chiefly in invention and the most progressive nations are those whose rate of invention is most rapid. Second, the greater foresight and solicitude for the future. As it is usually the normal healthy man who provides life insurance for his family, so it will be the normal healthy nation whch will take due care of its resources for the benefit of generations yet unborn.

SUMMARY OF CHAPTER XIV—THINGS WHICH NEED TO BE DONE.

SECTION 1. *Enumeration of principal measures.*—Federal, state, and municipal boards of health should be better appreciated and supported. Their powers of investigation, administration, and disseminating information should be enlarged. School hygiene should be practiced, and personal hygiene more emphasized. The multiplication of degenerates should be made impossible.

INTRODUCTION.

At the conclusion of his White House address on the "Conservation of Natural Resources," President Roosevelt said:

> Finally, let us remember that the conservation of our natural resources, though the gravest problem of to-day, is yet but part of another and greater problem to which this nation is not yet awake, but to which it will awake in time, and with which it must hereafter grapple if it is to live—the problem of national efficiency.

The conditions on which national efficiency depend may be classified under three heads: Those relating to physical environment, those relating to social environment, and those relating to human nature. Under the first head comes the problem of the conservation of land, forests, minerals, and water. The second comprises social questions, whether political, economic, or religious. The third covers the study of the characteristics of man himself—physical, mental, and moral.

This report falls under the third head, concerning as it does vitality, the measure of life itself, and the basis of all human qualities. The object is to review briefly the condition of American vitality, contrasted with the vitality of other nations; to show the extent to which it may be increased; and to point out the value of such an increase in years of life, enjoyment of life, and economic earnings.

The world is gradually awakening to the fact of its own improvability. Political economy is no longer the "dismal science," teaching that starvation wages are inevitable from the Malthusian growth of population, but is now seriously and hopefully grappling with the problem of abolition of poverty. In like manner hygiene, the youngest of the biological studies, has repudiated the outworn doctrine that mortality is fatality, and must exact a regular and inevitable sacrifice at its present rate year after year. Instead of this fatalistic creed we now have the assurance of Pasteur that "It is within the power of man to rid himself of every parasitic disease," as well as the optimistic writings of Metchnikoff and others.

Many evidences of a world-wide awakening to the importance of improving human vitality can be given. Among them are the recent English parliamentary report of the interdepartmental committee on physical degeneration (prompted by the fact that the English army recruits were decreasing in stature); in America, the many societies and congresses to prevent and control tuberculosis, insanity, alcoholism, social diseases and vice, and infant mortality; the growth of preventive sanatoria, dispensaries, and similar institutions; the establishment of numerous journals of preventive medicine, both technical and popular; the increased attention to the subject of health in the public press; the spread of athletics and the physical training movement; the growth of the custom among city people to organize country clubs, and the increasing popularity of golf and similar recreations; the constant agitation and legislation in reference to child labor, slaughterhouses, impure foods, milk supply, and water contamination; the increased vigilance of health boards; the growth of sick-benefit associations and insurance among working men; the efforts toward improving the sanitary surroundings and hours of labor of workmen, and especially of women and children, and, finally, the movement to secure a national organization of health at Washington.

A number of universities are supporting special investigations in physiology, hygiene, and preventive medicine. Some schools also have placed the allied subjects of domestic science and dietetics on their curricula, while physical education is receiving constantly increasing attention. Within a generation every important college, school, and branch of the Young Men's Christian Association has come to have a gymnasium and classes in gymnastics. Research institutions are being established, such as the Rockefeller Institute for Medical Research, the fund established by Mrs. Sage to study diseases of old age, and the Memorial Institute for Infectious Diseases. The home-economics movement is rapidly growing and seems destined to improve greatly the management of American homes.

The practice of medicine, which for ages has been known as the "healing art," is undergoing a gradual but radical revolution. The change is based on the conviction that an ounce of prevention is worth a pound of cure. As teachers and writers on hygiene, as trainers for athletes, as advisers for the welfare departments of large industrial plants, and in many other directions, physicians are finding fields for practicing preventive medicine. There is a still higher stage of medical science than that of fighting or preventing disease in the individual—the stage which has been called "biological engineering," i. e., the study of the conditions under which the individual may reach his highest efficiency. In the development of this science physicians are turning from private practice to public service and are acting as health officers in federal, state, and city governments, as heads of sanatoria and as medical inspectors of schools, factories, mines, and shops. Even the family physician is in some cases being asked by his patients to keep them well instead of curing them after they have fallen sick.

Finally, we have also the suggestion by Sir Francis Galton of the new science of eugenics, which seeks to study the hereditary conditions of human vitality. He has established a research fellowship on the subject at the University of London. Already Karl Pearson and others have made valuable contributions to the study of human degeneration, the effect of tuberculosis on the race, the comparative number of offspring of various classes, and the extent to which mating is "assortative," so that like marries like.

With all these facts in view it requires no great prophetic vision to see that among the rising generation there will be a great movement to conserve human life and health. The power and success of this movement will depend upon the realization of its stupendous importance. A chief object of this report is, in a conservative and cautious manner, to help make this importance clear.

Part I.—THE LENGTH OF LIFE VERSUS MORTALITY.

CHAPTER I.—*The length of life.*

SECTION 1.—*In different places.*

By those who have never considered the problem, death and disease are accepted as a matter of course. In individual cases it is recognized that a death or an illness might have been prevented, but the idea that the death rate could be changed in any appreciable degree, or controlled, is quite foreign to the mind of the average man. Charles Babbage wrote: "There are few things less subject to fluctuaton than the average duration of life of a multitude of individuals."[a]

If this statement were correct, we should find the average duration of life[b] and the death rate substantially the same in different places and at different times. The facts do not conform to this view. Modern life tables show that the average length of life in the leading countries of the world varies remarkably, as the following figures will illustrate.[c]

Modern duration of life.

Country.	Males.	Females.
Sweden, 1891-1900	50.9	53.6
Denmark, 1895-1900	50.2	53.2
France, 1898-1903	45.7	49.1
England and Wales, 1891-1900	44.1	47.7
United States (Massachusetts, 1893-1897)[a]	44.1	46.6
Italy, 1899-1902	42.8	43.1
Prussia, 1891-1900	41.0	44.5
India, 1901[b]	23.0	24.0

[a] Samuel W. Abbott, M. D.: "Vital Statistics of Massachusetts for 1897," Thirtieth Annual Report of the State Board of Health of Massachusetts, 1898.

[b] Statistiques Generale de la France: Statistiques Internationales, etc., 1907, p. 566. See also J. A. Baines, "The Peradventures of an Indian Life Table," Journal Royal Statistical Society, 1908, Vol. LXXI, part 2, p. 310, where the average duration of life for males is given as 23.6.

When we consider that the average duration of life in India is scarcely more than one-half that of France and less than one-half that of Sweden, we must conclude that the length of human life is dependent on definite conditions and can be increased or diminished by a modification of those conditions.

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[a] Charles Babbage: A Comparative View of the Various Institutions for the Assurance of Lives, p. 15. London, 1826.

[b] By average duration of life or the life span is meant the average length of life among a large number of persons born taken at random. It is not the same as the average age at death in a community during a year, since that community may contain an abnormally large proportion of infants, or of any other "age group."

[c] Some of the figures, especially those for India, rest on imperfect data, but they are believed to be sufficiently accurate for general comparison.

SECTION 2.—*At different times.*

Striking corroboration of this conclusion is found as soon as we compare the average duration of life at different periods of time. The earliest attempt to discover a law of human mortality appears to be that of Ulpian, a Roman pretorian prefect, about 220 A. D. The meaning of his table is somewhat doubtful, but it is assumed to refer to "expectation of life," which for ages up to 20 is given as thirty years.[a]

This estimate is so crude and vague as to be of little value for comparative purposes. Professor Finkelnburg, of Bonn, estimates that—

> The average length of human life in the sixteenth century was only between eighteen and twenty years, and that at the close of the eighteenth century it was a little over thirty years, while to-day it is between thirty-eight and forty years.[b]

In Geneva the records go back over three centuries showing the following life span:[c]

16th century	21.2
17th century	25.7
18th century	33.6
1801-1883	39.7

Here we see an increase in the span of life of 100 per cent in three or four centuries. The last few decades, moreover, tell a striking story of increase. It is one of the boasts of the nineteenth century that the splendid medical and scientific advances of that period have aided in a distinct lengthening of life.

In 1693 the British Government borrowed money by selling annuities, and in 1790, a century later, it did the same thing. While the first venture proved satisfactory, the second caused a great loss to the Government, owing to the improvement in longevity which had taken place, and which was estimated, for the annuitant class, at 20 years.[d]

If we compare Ogle's English life tables for 1871-1881 with those of Farr for 1838-1854, we find an increase in life span of 1.4 years for males and 2.8 for females.[e]

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[a] See Irving Fisher: Mortality Statistics of the United States Census, Publications of the American Economic Association, Monograph on Federal Census, 1899, p. 157. Taken from Assurance Magazine, VI, p. 314; note.

[b] George M. Kober, M. D.: "Conservation of Life and Health by Improved Water Supply," publications of conference on the conservation of natural resources, 1908, p. 23. Washington, D. C., privately published. From Finkelnburgs' "Organisation der öffentl. Gesundheitsphlage in der Kulturstaaten" in Handbuch der Hygiene, 1893.

[c] From Mallet in "Annales d' Hygiene," XVII, 169; quoted by Dr. Edward Jarvis, "Political Economy of Health," in Fifth Annual Report, Mass. Board of Health, 1874.

[d] See Dr. Southward Smith, Transactions British Social Science Association, 1857, p. 498, quoted by Dr. Edward Jarvis, ibid.

[e] R. Mayo-Smith; Statistics and Sociology, p. 178. New York (Macmillan), 1895.

A still greater improvement has been effected since Ogle's figures of 1871–1881:

Lifetime in England and Wales:

Males—	
1838–1854	39.9
1891–1900	44.1
Females—	
1838–1854	41.8
1891–1900	47.8

Similar improvements are observable in other countries.

Lifetime in France:

Males—	
1817–1831	38.3
1898–1903	45.7
Females—	
1817–1831	40.8
1898–1903	49.1

Lifetime in Prussia:

Males—	
1867–1877	35.3
1891–1900	41.1
Females—	
1867–1877	37.9
1891–1900	44.6

Lifetime in Denmark:

Males—	
1835–1844	42.6
1895–1900	50.2
Females—	
1835–1844	44.7
1895–1900	53.2

Lifetime in Sweden:

Males—	
1816–1840	39.5
1891–1900	50.9
Females—	
1816–1840	43.5
1891–1900	53.6

It is difficult to obtain American life tables that go far enough back into history to display increases in the life span similar to those just presented; yet comparisons of Abbott's Massachusetts life tables for 1893–1897 with Elliott's Massachusetts tables for 1855 and Wigglesworth's Massachusetts and New Hampshire life tables of a century ago give us a progressive increase from 35 in 1789 [a] to 40 in 1855 [b] and 45 in 1893–1897.[c] Unfortunately no tables exist for the United States as a whole from which similar comparisons might be made. Good and reliable vital statistics are among our most crying needs. Meech's life tables, based on the census figures of 1830, 1840, 1850, and 1860, showed a life span for the whole country of 42.[d]

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[a] E. Wigglesworth: "Table showing the probability of the duration, the decrement and the expectation of life in the States of Massachusetts and New Hampshire, formed from 62 bills of mortality on the files of the American Academy of Arts and Sciences in the year 1789." Memoir of the American Academy of Arts and Sciences, Vol. II, p. 133.

[b] Proceedings American Association for the Advancement of Science, 1857, pp. 61 and 69.

[c] Abbott, loc. cit.

[d] Levi W. Meech: System and Tables of Life Insurance, ed. of 1886, pp. 255–259. The figures for life span at different periods given in this paragraph have been secured by averaging the figures for males and females.

The census of 1880 gave some 70 sets of life tables for different registration States and cities. The expectation of life for white males was given for Massachusetts as 44, New Jersey 46, District of Columbia 41, and New York City 33, but in constructing the tables "the census was too prodigal as to quantity and somewhat careless as to quality. It is difficult to separate the wheat from the chaff. The table should have been accompanied by a running criticism. The general defect was that no attempt was made to correct the deficiencies in the returns for infants."[a] The census for 1890 gives only a few life tables, and that for 1900 none.

In striking contrast to these recent increases of the life span in progressive countries is the table for backward India, which showed no advance in twenty years.[b]

Lifetime in India:	
Males—	
1881	23.7
1901	23.6

CHAPTER II.—*The mortality rate.*

SECTION 1.—*Relation of longevity and mortality.*

The average duration of life and the death rate[c] are two complementary magnitudes. An increase in the life span means a decrease in the death rate, and vice versa; in fact, in a "stationary" population (a population in which the annual number of deaths equals the annual number of births, and without emigration or immigration), it will be true that the average duration of life and the death rate are mathematically the "reciprocals" of each other.[d] Thus, if the death rate is 20 deaths per annum for each 1,000 of population (i. e., twenty one-thousandths per annum), the average duration of life would be $\frac{1000}{20} = 50$ years.

If this reciprocal relation between duration of life and mortality held true in every population, it would be easy to translate death rates into average duration of life, and conversely; but unfortunately such a simple calculation is impracticable under conditions existing in America, and even in most countries of Europe. With the exception of France, few countries have even approximately an equality between deaths and births and an absence of emigration and immigration. In America, where the deaths are exceeded by the births, and where there is a large immigration of young men and women in the prime of life, the death rate is smaller than it would be if our population were "stationary." The annual death rate in the United

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[a] Fisher: Mortality Statistics of the United States Census, American Economic Association Monograph on the Federal Census, 1899, p. 160.

[b] Baines: "The Peradventures of an Indian Life Table," Journal of the Royal Statistical Society, 1908, Vol. LXXI, pt. 2, p. 310.

[c] A death rate is the ratio of the number of deaths during a year to the population, taken at some point in the year, usually the middle.

[d] For a short explanation of this reciprocal relation, which is more fully explained in works on actuarial science, see Fisher: Mortality Statistics of the United States Census, pp. 149–150. It is interesting to see the graphic interpretation of this reciprocal relation by means of the diagram in Chapter XI of this Report.

States is probably about 18 per thousand[a] of population. The reciprocal of this would be 1,000÷18, or 55 years, which is altogether too high an estimate for the average length of life in the United States.

It is possible to "correct" the death rate for "age distribution" so that its reciprocal will be the true average duration of life, but the calculation is a difficult and tedious one. We are forced, therefore, to get along in most cases with the "crude death rate," or the quotient of the number of deaths in a year divided by the population. This figure is much easier to obtain than a corrected death rate or its reciprocal, the average duration of life.

Our data for death rates are far more voluminous than our data for the average duration of life. Although theoretically death rates are not an unerring indication of longevity, they furnish in practice very valuable information. In a general way death rates may be compared with each other, especially in the same community. For instance, a decrease in the death rate in New York City from one year to another is practically a certain indication of improvement in vital conditions.

SECTION 2.—*Mortality in various regions.*

Forty years ago the variations in the death rates of the different sections of Europe were given by Quetelet[b] as follows:

Death rate per 1,000 population.

Northern Europe	24.3
Central Europe	24.5
Southern Europe	29.7

To-day the death rates of various countries compare with each other as in the following table:

Modern death rates per 1,000 of population.[c]

Denmark (1906)	13.5
Sweden (1906)	14.4
England and Wales (1906)	15.4
United States (registration area) (1907)	16.5
Germany (1905)	19.8
France (1906)	19.9
Italy (1906)	20.8
Japan (1905)	21.9
India (males,[d] 1901)	42.3

As we found in the study of duration of life, so we find here wide variations from country to country. Italy presents a death rate larger by nearly one-sixth than that of the United States, while famine-tortured and plague-ridden India's mortality rate is twice that of France and three times the rates of Denmark and of Sweden.

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[a] W. F. Willcox: "Death Rate of the United States in 1900," publications of the American Statistical Association, Vol. X, p. 155.

[b] Quetelet, Physique Sociale, Vol. I, p. 281. These figures refer to the experience of different periods between 1801 and 1831.

[c] With the exception of the figures for India, this table is taken from figures furnished by the Bureau of the Census.

[d] Baines, loc. cit., p. 310.

Even the fairly homogeneous population of our registration States in America shows variations in death rates.[a]

Death rate per 1,000 population in 1900.

Michigan	13.9
Vermont	17.0
Massachusetts	17.7
New York	17.9

The death rate in Michigan, at the one extreme, is thus but three-fourths that of New York at the other extreme. This difference may probably be accounted for in part by the difference in the age constitution, as the population for Michigan contains a larger proportion of population in young and vigorous life than does New York.

SECTION 3.—*Urban and rural mortality.*

Comparison of urban and rural death rates also gives us variations.[b]

Death rates per 1,000 population in 1900.

Massachusetts:	
Urban	17.9
Rural	17.1
Michigan:	
Urban	15.3
Rural	13.3
New Jersey:	
Urban	18.8
Rural	15.5

Interesting comparisons may be made of the death rates of American cities varying in size and location. The death rate per 1,000 of population in 1906 was given[c] as 14.2 (probably incorrect) in Chicago, in Boston 18.9, in New York 18.6, and in Philadelphia 19.3. Cleveland, Ohio, was credited with a death rate of but 16, while Cincinnati, in the same State, had 20.8. The causes of such differences are not always attributable to variations in size. New Haven, for instance, a larger Connecticut city than either Hartford or New London, had a lower death rate in 1900 by 2.2 and 2.5, respectively, per 1,000 population. The differences are accounted for partly by differences in age constitution, partly—it is unfortunately true—by differences in the accuracy of the collected statistics, partly by differences in size and location, and partly by differences in the vigilance of the public and private health authorities.

European cities show even greater variations in mortality than these just given for the United States.

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[a] Twelfth Census of the United States, Vol. III, p. LVIII.

[b] United States Census Bulletin, No. 83, 1901.

[c] Seventh Annual Census Report on Mortality Statistics, 1906.

Death rates of European cities per 1,000 population, 1897.[a]

Locality.	High.	Locality.	Low.
Dublin	39.9	Frankfort on the Main	15.6
Moscow	36.9	The Hague	16.2
Belfast	31.3	Berlin	17
St. Petersburg	31	Amsterdam	17.8

[a] One must doubt, however, the accuracy of some of these figures, especially the Russian. The rates in Moscow and St. Petersburg in 1906 are reported as 25.8 and 25.5, respectively, which do not comport with the rates for 1897.

SECTION 4.—*Race and condition.*

The variations in death rates among different races are well known. The black race, for example, always suffers a higher mortality than the white. In Boston during the half century from 1725 to 1774 the death rate per 1,000 is given as ranging from 56 to 87 for the blacks and only from 30 to 41 for the whites. Thus the maximum white death rate was lower than the minimum black death rate.[a]

In 1906 the death rate per 1,000 in all registration cities having not less than 10 per cent colored inhabitants was 17.2 for whites and 28.1 for blacks.

These racial differences may be ascribed in part to different habits and conditions of life, but probably in part also to varying racial susceptibility to disease.

The relation of social status to the rate of mortality has been often discussed and offers a partial explanation of racial or national variation of death rate. That a well-to-do class, properly fed and clothed and with opportunity for leisure, will be less susceptible to disease and death than a poverty-stricken class, ill-fed and overworked, has been repeatedly shown by statistics. Newsholme has stated,[b] for example, that in Glasgow the death rate among tenants of large houses is much lower than among the tenants of smaller dwellings:

	One and two room houses.	Three and four room houses.	Five rooms and over.
Death rate per 1,000 occupants in 1885	27.7	19.5	11.2

In Paris comparison has been made between two quarters known to be rich, on the one hand, and, on the other, a third quarter known to be poor.

Death rate per 1,000 population.[c]

Rich quarters:	
Elysee	13.4
Opera	16.2
Poor quarter:	
Menilmontant	31.3

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[a] Lemuel Shattuck, "The Vital Statistics of Boston," p. xiii. Reprinted in "Bills of Mortality, 1810–1849," city of Boston, 1893.

[b] Arthur Newsholme, "Vital Statistics," London (Swan Sonnenschein), 1899, p. 163.

[c] E. Levasseur, "La Population Francaise," Paris, 1891, Vol. II, p. 403.

In Russia a similar comparison has been made between peasants who own no land, those who own less than 13½ acres, those who own between 13½ and 40½ acres, and so on up the scale of proprietorship.[a]

Peasant death rate per 1,000, Government of Voronezh, 1889–1891.

Class of household.	Per 1,000.
Having no land	34.7
Having less than 13.5 acres	32.7
Having 13.5 and less than 40.5 acres	30.1
Having 40.5 and less than 67.5 acres	25.4
Having 67.5 and less than 135 acres	23.1
Having more than 135 acres	19.2

Occupational comparisons are often made; and while they must be handled with great care, especially because of differences in age, the following may be said to display roughly the variations in death rate among social classes.

Death rate of males per 1,000, according to occupations, for registration States, 1900.[b]

Mercantile and trading	12.1
Clerical and official	13.5
Professional	15.3
Laboring and servant	20.2

Special industries have high death rates from special diseases. Among dusty trades, for instance, tuberculosis is very common.[c]

Finally, the experience of industrial life-insurance companies, which deal largely with the poorer classes of society, shows a higher death rate than that displayed by the experience tables of other insurance companies.[d]

Insurance mortality per 1,000.

Age	Ordinary insurance, English experience.	Industrial insurance, Metropolitan Life.
20	7.3	10.5
25	7.8	14.1
35	9.3	17.2
55	21.7	35.2
70	64.9	91.0

We find also great variations in death rates dependent on varying climatic or seasonal conditions, on the prevalence or absence of certain pests, on the fluctuating virulence of specific diseases, and on numerous natural differences. Other significant factors in mortality are historical events, such as wars, plagues, and epidemics. Hard times bring increased mortality, whether due to natural or politico-economic causes. There remain to be mentioned also deaths by accident in all its many forms.

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[a] I. M. Rubinow, "Poverty's Death Rate," publications of the American Statistical Association, December, 1905, p. 348.

[b] "Twelfth Census of the United States," Vol. III, p. cclxi.

[c] See Frederick L. Hoffman, "Mortality from Consumption in dusty trades," Bulletin No. 79 of the U. S. Bureau of Labor.

[d] Haley Fiske, "Industrial Insurance," The Charities Review, March 1898, p. 33.

SECTION 5—*Mortality historically.*

Not only does the death rate vary greatly from place to place and from one social class to another, but it changes in a most marked fashion from period to period in history. The records of old cities show that a decided decrease in mortality has been steadily going on. In London, for example, the rate per 1,000 has fallen from 50 in 1660-1679 to 15 in 1905, a decrease of 70 per cent. In the plague years, 1593, 1625, 1636, and 1665, the death rates per 1,000 were 240, 310, 130, and 430.[a] The "black death" in 1348-9 probably swept away half of the population in many localities throughout Europe.[b]

Mortality in London.[a]

Year.	Rate per 1,000.
1660-1679	50
1680-1728[b]	80
1729-1780	40
1905	15.1

[a] Kober, *loc. cit.*, p. 25.
[b] These years include the period of pests.

Within a quarter century London has cut her death rate in half, while Vienna, if we may trust the figures, has within a century reduced her rate from 60 per 1,000 of population to 23.[c] Similarly, the mortality rate in Boston has been lowered from an estimated 34 per 1,000[d] in 1700 to 19 to-day.

Mr. John K. Gore, actuary of the Prudential Insurance Company, shows[e] that the average death rates per 1,000 of population among typical American cities was, for the white population, as follows:

Years.	Death rate per 1,000.
1804-1825	24.6
1826-1850	25.7
1851-1863	28.3
1864-1875	25.4
1876-1888	22.9
1889-1901	21.0

The record even of the last thirty years displays a fall in death rates that may inspire us with buoyant hope for the future. The mortality rate per 1,000 has fallen in Berlin from 33 in 1875 to 16 in 1904; in Munich, from 41 in 1871 to 18 in 1906; and in Washington, from 28 in 1875 to 19 in 1907.[f]

Between 1890 and 1906 New York lowered her death rate per 1,000 from 25.4 to 18.6, and Boston from 23.4 to 18.9. The mortality rate in the whole registration area of the United States fell from 19.6 per 1,000 in 1890 to 16.1 in 1906, although the area in the last-named year included a larger proportion of urban population.

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[a] See Farr, Vital Statistics, London, 1885, p. 131.

[b] See Abbot Gasquet, "The Black Death of 1348 and 1349," London (Bell), 1893.

[c] A. F. Weber, "The Growth of Cities," New York, 1899, pp. 355, 356.

[d] Shattuck, *loc. cit.*, pp. xii-xiv.

[e] "On the Improvement in Longevity in the United States during the Nineteenth Century."

[f] Kober, *loc. cit.*, p. 25.

We have also vital records for the city of Habana, running back over a century. These show that while the death rate in 1802 was given as 54.6 per 1,000, rising in cholera years even as high as 103.4 (1833) and in the last year of Weyler's concentration methods as high as 91, the rate during the eight years from 1899–1906 ranged from 20.4 to 33.6.[a]

These records also show the remarkable and sudden fall that may be brought about by a change in the living conditions of a community. During the three "concentration" years of 1896, 1897, and 1898 the mortality rate per 1,000 was 51.7, 78.7, and 91, respectively. In 1899, the first complete year of American occupation, the rate dropped to 33.6, and since then it has ranged between 20.4 and 24.4. There can be no question that the improvement was almost wholly due to the sanitary reforms introduced by Colonel Gorgas, and the other United States Army surgeons under Gen. Leonard Wood.

The record of American Army sanitarians in the Panama Canal Zone shows as striking results as in Cuba. The death rate in Panama during 1887, when the French canal companies held occupation, ran over 100 per 1,000. In 1906 the death rate was 49 per 1,000, while in 1907 it fell to less than 34. Colonel Gorgas attributes the decrease in the general death rate in great part to improved sanitation, though he adds that "increased wages, better food, and better clothing have no doubt played a considerable part in the general improvement of the health."[b]

SECTION 6.—*Adult and infant mortality.*

Mortality varies greatly with age. The improvement in the city death rate of the past half century has been especially marked among the young.

It is true that in countries of the same degree of civilization the infant death rate is remarkably constant,[c] but this is probably accounted for by the similarity in the methods of feeding of infants. Certainly where there is a difference in conditions there will be found a difference in mortality. Thus, the comparison between the mortality of infants fed on cow's milk and those fed on mother's milk shows that the former is five to ten times that of the latter.[d]

Although the infant mortality rate is probably falling,[e] the decrease is not accompanied by a lowering of the mortality of later life. There is an increased mortality beyond the age of 50 years. In Massachusetts the death rates by age changed during thirty years as follows:

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[a] "Report of the National Sanitary Department of the Republic of Cuba," Habana, 1906, p. 78.

[b] Letter from Col. W. C. Gorgas, chief sanitary officer, Canal Zone.

[c] See E. B. Phelps, "A Statistical Study of Infant Mortality," quarterly publication of the American Statistical Association, September, 1908. Mr. Phelps shows the utter unreliability of most statistics of infants under 1 year of age, especially in the United States.

[d] See Harald Westergaard, "Mortalität und Morbilität," Jena, 1901, p. 364.

[e] Edward E. Graham, M. D., "Journal of the American Medical Association," September 26, 1908; also "British Medical Journal," February 1, 1908, p. 271.

Death rate in Massachusetts per 1,000 of population in each age period.[a]

Age.	1865.	1895.
5-9	9.6	6.2
10-14	5.1	3.2
15-19	9.6	5.3
20-29	12.6	7.1
30-39	11.7	9.7
40-49	12	13
50-59	17	20
60-69	33	39
70-79	70	82
80 and upward	168	185

[a] "Vital Statistics of Massachusetts," 1856–1895, p. 755.

Here, while the death rate for all age periods under 40 has materially decreased, the later periods of life have suffered progressive increases in mortality rate.[a]

As Frederick L. Hoffman has expressed it:

> There is, of course, no question whatever that the American death rate, using the term in a very comprehensive sense, has substantially declined within the last fifty years, but it is equally evident that this decline has been at the younger ages, and not during the period of life which, economically, is of the greatest value. There is no doubt that the mortality of adult ages is still decidedly excessive.

The same tendency, viewed from the standpoint of the expectation of life,[b] is disclosed in the study of two Massachusetts life tables, compiled nearly a century apart—one, Wigglesworth's life tables for Massachusetts and New Hampshire in 1789, though not very accurate; the other, Abbott's Massachusetts life tables for 1893–1897.

Expectation of life in Massachusetts.

Age.	1789.	1897.	Age.	1789.	1897.
0	35.5	45.4	60	15.4	15.1
10	43.2	50	80	5.9	6.1
20	34.2	42	90	3.7	3.4
40	26	28.2			

These figures indicate that the expectation of life at the earlier ages is much greater than a century ago, but that for the age of 60 and upward it has remained practically stationary.

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[a] At first sight it would seem that this increased mortality in later ages could be explained away as due to the larger number of persons who are saved from earlier death and tend to produce a higher mortality at the older ages. I speak of this because very intelligent persons have drawn this conclusion. But it is obviously fallacious, since the figures do not indicate the *number* of deaths in different periods, but the death *rates* in different periods of life per 1,000 at each period. There are, to be sure, as a consequence of saving lives in the past, more old men now living than otherwise there would be, and there will be more deaths, but the figures show that these old deaths have increased faster than the number of old men. This fact raises the suspicion, therefore, that the lives which have been saved by the hygiene of a generation ago are weak lives. Whether this is a tenable hypothesis or not will be discussed in Chapter X.

[b] "Expectation of life" at any given age is the mean after-lifetime of persons who reach that age. Thus 100 persons have an expectation of life of 50 at the age of 10, if the total life to be lived by those 100 persons before death is five thousand years.

English life tables[a] for three decades ending 1900 display the same tendency.

English life tables—Expectation of life.

Age.	1871-1880.	1881-1890.	1891-1900.
MALES.			
0	41.4	43.7	44.1
20	39.4	40.3	41
60	13.1	12.9	12.9
80	4.8	4.5	4.6
FEMALES.			
0	44.6	47.2	47.8
20	41.7	42.4	43.4
60	14.2	14.1	14.1
80	5.2	5	5.1

These tables show that there is improvement at the younger ages for the period 1891–1900 over the period 1871–1880. For ages over 60 there has been a retrogression. It is observable, however, that between the periods 1881–1890 and 1891–1900 the figures for 60 years have remained stationary, and for 80 have slightly improved.

In other words, a baby to-day has in prospect a much longer average lifetime than did the baby of two generations ago; but a man or woman 60 years old has in prospect an average after lifetime no greater than formerly.

The proximate cause of this contrast would seem to lie in the fact that the mortality from many of the diseases of later life has been and is on the increase. The death rates from diabetes, heart disease, and Bright's disease have all doubled in thirty years.[b]

Cancer is probably on the increase,[c] and "to-day one in every 21 men who have reached the age of 35 and one in every 12 women who have reached 35 eventually die of that disease."[d]

In addition, there may be mentioned other diseases, arteriosclerosis, nephritis, apoplexy, paresis, disorders of the liver, and all manner of degeneration, all of them maladies of adult life, and all of them apparently tending to increase.

SECTION 7.—*Particular diseases.*

We turn now to the ravages made by particular diseases in the modern world. The death rate in the United States from tuberculosis of all forms equals the combined death rate from smallpox, typhoid fever, diphtheria, cancer, diabetes, appendicitis, and meningitis.

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[a] "Supplement to Sixty-fifth Annual Report Register-General of England and Wales," pt. 1, 1907, p. XLVIII–LI.

[b] Norman E. Ditman, M. D., "Education and its Economic Value in the Field of Preventive Medicine," Columbia University Quarterly, Supplement to June, 1908, p. 38.

[c] Elie Metchnikoff, "The Nature of Man," English translation, New York (Putnam), 1903, pp. 213, 214; see also "United States Census mortality statistics, 1906," p. 29.

[d] Ditman, loc. cit., p. 38.

The death rate from tuberculosis of all kinds in the registration area was 183.6 per 100,000 in 1907.[a] The rate is high among negroes.[b] Large as these figures are, they represent a considerable decrease since 1900.[c] Tubeculosis is a preventable disease.

On a par with tuberculosis in the number of its victims in this country stands pneumonia.

The mortality statistics of the last census show that in the registration area of the United States pneumonia is responsible for 11 per cent of all deaths. Pneumonia is now known to be a communicable disease, the germ of which is very widely distributed; but there is great need for special researches into the modes of spreading this formidable disease. In the meantime the best protection is to "keep in condition." While the germ of pneumonia is the exciting cause of the disease, predisposing causes are acute or chronic alcoholism, exposure to cold, extreme exhaustion, and debility of any kind.

Typhoid fever is in some places yielding to preventive measures in a most striking manner. The fall in the death rate from typhoid in the registration area from 46.3 per 100,000 of population in 1890 to 33.9 in 1900,[d] and to 32.1 in 1906,[e] may be safely ascribed to improvements in the water and milk supplies of our cities. The surprising reduction of the typhoid-fever death rate in individual cities, resulting from definite improvements in the water supply, gives direct confirmation of this statement.

The typhoid mortality in Munich during 1856 was 291 per 100,000 of population. The city at that time contained numerous cesspools, and the water supply was largely obtained from wells and pumps. From 1856 to 1887 there was great activity in the filling up of cesspools, the abandonment of pumps and wells, and the installation of modern sewers. A pure water supply was also secured, the water being brought from a distance. The typhoid-fever death rate fell in 1887 to 10 per 100,000 of population—a reduction of 97 per cent.[f]

In Hamburg the typhoid mortality for 1880–1892 ranged from 24 to 88, averaging 39.7 per 100,000. In May, 1893, a filtration plant was opened, and the rate fell in that same year to 18. For the five years following it averaged only 7.2, showing a reduction of over 80 per cent.[g]

The introduction of a water filter in the town of Lawrence, Mass., in 1893 was followed by a reduction in deaths caused by typhoid from 105 in 1892 to 22 in 1896, one-fifth the previous figure. Filter-ing the city water in several other American cities has shown abrupt declines in the typhoid death rate almost as remarkable.[a]

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[a] For a careful statistical study of tuberculosis see "Tuberculosis in the United States," United States Census, issued for the International Congress on Tuberculosis, 1908. See also "Bulstrode's Report in Thirty-fifth Annual Report of (English) Local Government Board, 1905–6," and Arthur Newsholme, M. D., "Prevention of Tuberculosis," 1908.

[b] For the prevalence of tuberculosis in the negro, see F. L. Hoffman's valuable monograph, "The American Negro," publications of the American Economic Association, August, 1896.

[c] This decrease is shown by the exact figures (not estimated) in the registration area.

[d] Twelfth Census of the United States, Vol. III, p. cxliv.

[e] Mortality Statistics, U. S. Census Office, 1906, p. 30.

[f] Ditman, loc. cit., p. 17.

[g] A. C. Abbott, M. D., "The Hygiene of Transmissible Diseases," Philadelphia, Saunders, 1899, pp. 88–89.

Another method of pointing out the importance of a pure water supply is to compare the mortality rates from typhoid fever of cities that secure water from various sources of supply, as the following table shows:[b]

Death rate from typhoid fever per 100,000 of population, 1902–1906.

4 cities using ground water from large wells	18.1
18 cities using impounded and conserved rivers or streams	18.5
8 cities using water from small lakes	19.3
7 cities using water from Great Lakes	32.8
5 cities using surface and underground water	45.7
19 cities using polluted river water	61.1

> Thus far our studies indicate that typhoid fever will cease to be a "problem" in any community having clean water and an uninfected milk supply, and in which cases of the disease are treated as dangerous and contagious."[c]

Unfortunately such communities are too rare at present.

Perhaps the most common and neglected source of danger of infection from typhoid is the ordinary house fly or, as Dr. L. O. Howard, chief of U. S. Bureau of Entomology, would have us call it, the "typhoid fly."

Smallpox, another disease that yields readily to preventive measures, has decreased greatly in virulence and mortality since the introduction[a] of vaccination. In Prussia, for example, the death rate from smallpox per 100,000 population was 24.4 in the period from 1846–1870. In 1874 vaccination, which up to that time had been only intermittently utilized, was made compulsory, and the death rate per 100,000 fell at once to 1.5 for the years 1875–1886.[d]

Other European States, however, have been more lax than Germany. In 1886 the death rate from smallpox in Switzerland was fifty-fourfold that of Germany; in Belgium, forty-eightfold; in Austria, eighty-onefold, and in Hungary, six hundred and sevenfold.[e]

Babbage[f] states that "it has been shown by M. Duvillard that the introduction of vaccination has increased the mean duration of human life about three years and a half." Before Jenner's utilization of vaccination to guard against smallpox that disease was causing one-tenth[g] of all deaths of the human race, just as does tuberculosis to-day, while "nearly twice as many were permanently disfigured by its ravages. In England 300 per 100,000 population died annually from it. It is computed that during the eighteenth century 50,000,000 people died of smallpox in Europe."[h]

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[a] See Kober, loc. cit., pp. 18, 19.

[b] Kober, loc. cit., p. 15.

[c] M. J. Rosenau, L. L. Lumsden, and Jos. H. Kastle, "The origin and prevalence of typhoid fever in the District of Columbia," Hygienic Laboratory Bulletin No. 44, 1908, p. 9.

[d] Ditman, loc. cit., p. 8.

[e] Floyd M. Crandall, "A century of vaccination," American Medicine, December 7, 1901.

[f] Loc. cit., p. 8.

[g] Crandall, loc. cit., p. 6.

[h] Ditman, loc. cit., pp. 6, 52–3.

Boston was visited twelve times by smallpox epidemics in the century and a half ending 1800.[a]

Yet where vaccination has been made compulsory, or where it is generally resorted to, smallpox has virtually disappeared. The last census reported but 3,500 deaths from smallpox in the United States in 1900. Even as long ago as 1826 Denmark was enforcing the practice of vaccination so vigorously that not a single case had appeared for eleven years.[b] Habana, during the eight years prior to the American intervention, reported 3,132 deaths from smallpox. In 1899, the year following the American entry, there were four deaths, and three more during the next seven years—a virtual uprooting of the disease.[c]

The present outcry against vaccination is based on a misunderstanding, and is one of many evidences of the imperative necessity of the diffusion of correct knowledge among the people on matters of hygiene and preventive medicine. Whether vaccination should be made compulsory is a fair question, but that it is efficacious is not open to question. The argument that because some unvaccinated persons escape during an epidemic all would escape is too absurd to deserve serious consideration.[d]

Yellow fever first appeared in serious form at Philadelphia in 1793, when one-tenth of that city's population died of it in the space of six and a half weeks. Since 1793 the United States has had 500,000 cases, resulting, it is estimated, in about 100,000 deaths. In 1900 it was discovered that a species of mosquito is responsible for the transmission of this fever, and in consequence of this knowledge and its application the disease is now practically banished from this country.[e]

The marked decrease in the death rate from yellow fever in Habana since the American intervention in 1898 is shown in the following table. The deaths from yellow fever numbered 4,420 in the eight years from 1891 to 1898, while in the eight years from 1899 to 1906 they numbered but 465.

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[a] Shattuck, loc. cit., p. xiv.

[b] Crandall, op. cit.

[c] Report of National Sanitary Department of the Republic of Cuba, Habana, 1906, p. 79.

[d] For the most scientific statistical studies of vaccination see W. R. Macdonnell, Biometrika, Vol. I, 1902, p. 375, and Vol. II, 1903, p. 135. J. Brownlee, Biometrika, Vol. IV, 1905–6, p. 313. F. M. Turner, Biometrika, Vol. IV, p. 483. Karl Pearson, Biometrika, Vol. IV, and Philosophical Transactions of the Royal Society of London, Series A, Vol. 195, p. 43. Humphreys, Journal of the Royal Statistical Society, 1897, p. 503. For the best of antivaccination literature see Alfred Russell Wallace, "The Vaccination Delusion," and Milnes, Journal Royal Statistical Society, 1897, p. 552 (Comment by G. U. Yale, p. 608). For both sides see Report of the Royal Commission on Vaccination, 1897.

[e] Ditman, loc. cit., pp. 11–12.

Yellow-fever death rate in Habana, 1870–1906.

[a] [Rate per 100,000 population.[a]]

Before American intervention.		After American intervention.	
1870	300.5	1898	67.8
1880	324.5	1899	42.5
1890	153.6	1900	124.0
1895	275.8	1901	6.9
1896	639.5	1902	0
1897	428	1903	0
		1904	0
		1905	8.0
		1906	4.3

[a] Report of the National Sanitary Department of the Republic of Cuba, 1906, p. 79.

These results have been due partly to the elimination of the contagion-carrying mosquito and partly to the general improvement of the city's sanitary appointments.

A similar contrast might be drawn between the death rates from yellow fever at Panama during the efforts of the French to dig the canal and during the American work under the sanitary regulations of Colonel Gorgas. If the same thoroughgoing measures used in Habana and at Panama were employed among our own people, the resultant blessings would be almost equally striking.

The impressive figures just presented, showing the fall in mortality from so many of the most dangerous diseases, point clearly to the value of preventive measures in the conflict with disease. The fall in tuberculosis mortality is directly due to the growing use of hospitals, which have tended to isolate[a] consumptives, and to a use of our recently acquired knowledge of the efficacy of fresh air and the outdoor life; typhoid fever has virtually disappeared when water and milk supplies have been made pure, the open privy abolished, and flies and other carriers of the specific cause of the disease have been provided against; smallpox has given way before vaccination; yellow fever is fast disappearing now that the agent of transmission is known; while many of the less serious diseases are losing their power, purely owing to preventive methods.

Some diseases, once the scourges of humanity, have practically disappeared from the civilized world.

Scurvy up to the latter half of the eighteenth century decimated the armies and fleets of Europe and afterwards proved a menace to the civilized population. During Anson's famous expedition about the year 1750, 600 out of 900 died, chiefly from scurvy. The use of lime juice and fresh vegetables has practically eradicated the disease.[b]

"Cholera was wont to visit the cities of the Atlantic coast in the past about every ten years, and it was a standing menace to the world every summer. It was not uncommon for the disease to decimate whole towns and cities. Since the discovery of its cause, however, it has been robbed of its terrors, and the children of to-day will probably never know of it except by name."

Malaria has been on the decrease ever since the discovery that the malarial organism is transported by a species of mosquito. Even the five years ending 1906 show a progressive decline in the death rate from malarial fever in the registration area. The figures are 5.4, 4.3, 4.2, 3.9, and 3.5 deaths per 100,000 of population, for the five years in question. In themselves, the figures are so small as to show the virtual disappearance of the disease, at least from the Northern States. It is still very common in the Southern States. Its evil is by no means to be measured by the deaths it causes. It produces chronic disability and predisposes to other diseases.[a]

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[a] See Arthur Newsholme, "The phthisic death rate," Journal of Hygiene, July, 1906.

[b] Ditman, loc. cit., 14–15.

Finally, the furnishing of pure milk to the infant population of the cities is eliminating year by year the infant scourges—diarrheal diseases and related maladies.

There are of course diseases which show no sign as yet of decreasing. The census volume, "Mortality Statistics of 1906" (p. 29) gives only one important disease (diabetes) as actually on the increase within the registration area, but several which are given as having "fluctuating rates," such as cancer, heart disease, and Bright's disease, seem still to have an upward trend.

It is known that malaria is preventable. Why, then, is it not prevented in the South? Probably for two reasons. First, the facts are not generally known, owing to lack of vital statistics in the Southern States. Second, owing largely to this ignorance no adequate effort has yet been made. As an example of what can be done we have the cleaning of Habana by Colonel Gorgas. The following table, supplied by him, shows the deaths from malaria from 1899 to 1907:

Year.	Number of deaths.	Year.	Number of deaths.
1899	909	1904	44
1900	325	1905	32
1901	151	1906	26
1902	77	1907	[a]23
1903	51		

[a] Annual Report of the Sanitary Department for the City of Habana for the year 1907.

"The first year quoted, 1899, the malarial deaths were excessive, owing to the crowding into the city of the 'reconcentrados' and the starvation and misery thereby involved.

The next year, 1900, was about the normal rate. The next year, 1901, begins to show the effect of the antimalarial work done in connection with the yellow-fever work; 1901 was the first year of mosquito work in Habana. The last year, 1907, shows only 23 deaths from malaria. This means practically the extinction of malaria in Habana. The item of 23 deaths in 1907 from malaria would probably be covered by the malarial cases coming in from the rural districts and by mistakes in diagnosis."

The preventability of accidents is beginning to be appreciated. It is now proposed by Mr. W. H. Tolman to establish in New York a museum of safety and sanitation to demonstrate this fact. Mr. Frederick L. Hoffman, statistican of the Prudential Insurance Company, estimates the number of deaths among male workers alone in 1908 as between 30,000 and 35,000.[b]

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[a] See "Report to the Conservation Commission" of L. O. Howard. "Economic loss to the people of the United States through insects that carry disease."

[b] "Industrial accidents," Bulletin of the Bureau of Labor, 1908.

Part II.—THE BREADTH OF LIFE VERSUS INVALIDITY.

CHAPTER III.—*Prevalence of serious illness.*

SECTION 1—*Loss of time.*

Length of life is but one indication of vitality. Everyone recognizes that the life of a valetudinarian or an invalid, however long, is but a narrow stream. We may therefore conceive, besides the dimension of length, another dimension of life which may be called its "breadth." By the breadth of life we mean its healthiness. Just as length of life is limited by and opposed to mortality or death, so breadth of life is limited by and opposed to invalidity or illness.

An ideally healthy life, free throughout from ailment and disability, is rarely if ever found. But it is the aim of hygiene to approximate such an ideal. Some persons imagine that length of life can be purchased only at the expense of breadth, and counsel the deliberate shortening of one's life for the sake of living it faster. In exceptional cases such a policy may be justified, but the study of longevity reveals the fact that, as a rule, length and breadth of life are not opposed, but that, on the contrary, the one can seldom be increased without an increase of the other. Centenarians are usually persons who have been exceptionally free from illness[a] and who have performed a large amount of work. This work is usually physical labor out of doors, although the few mental workers completing the century have also lived busy lives.

Chevreul, the distinguished French chemist who died twenty years ago at the age of 103, lived a life of great activity and usefulness as laboratory experimenter, as industrial chemist, as university professor, and as a writer and lecturer. It was said of Alexander Von Humboldt, who was 90 at the time of his death, that he had not only lived twice as long as others in years, but that in work accomplished he had lived twice as much per day, thus enjoying four times the average lifetime.

It is shortsighted to spend more vitality each day than we earn. Such a policy must not only prove suicidal sooner or later, but tends to narrow one's life in every way long before the arrival of death. The ordinary individual burns the candle at both ends. The result is an almost universal invalidism in some degree. While statistics are lacking, a wide observation seems to justify the conclusion that it is difficult to find a man or woman over 40 whose health has not become impaired in some manner. Few who have not studied the facts realize how common illness is, although we all know it is sufficiently common to make the question "How are you?" the ordinary form of salutation.

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[a] Metchnikoff, "The Prolongation of Life," English translation, New York, (Putnam's) 1908, p. 145.

Serious illness is such as totally incapacitates a person from work, whether or not he is confined to his bed. The burden of serious illness is felt in several distinct ways. There is the annual idleness entailed by this illness, the cost of maintaining institutions devoted to the care of the sick, and the cost to the individual of medicines, medical service, and nursing.

The amount of invalidity or illness in a community has been estimated by a number of different investigators, and in a number of different ways. While the results vary somewhat, on the whole they harmonize fairly well.[a]

The most careful consideration of the various illness statistics available was made by Farr. He finds that the rate of invalidity increases with age, and at the later ages increases with great rapidity. The material he has used has come chiefly from various friendly societies in Great Britain and Scotland, and especially from the East India Company. His final conclusion is probably nearly as valid to-day as then. It is that corresponding to each death in a community, there are a little more than two years of illness.

Another way of expressing the same fact is that for each annual death, there are on the average two persons constantly sick during the year. Applying this estimate to the United States,[b] in which about 1,500,000 persons die per annum, there are probably at all times about 3,000,000 persons seriously ill. This means an average of thirteen days per annum for each inhabitant.[c]

Returns gathered from 79 benefit societies in Scotland, aggregating over 100,000 members, and based on the experience of various periods between 1750 and 1821, showed that the average duration of sickness for each member under seventy years of age was ten days per year, 2 of which were assumed to be "bedfast" days, five as days of walking sickness, and three as days of permanent sickness.[d]

SECTION 2—*Particular diseases.*

It has been estimated that the number of persons in the United States constantly suffering from tuberculosis reaches 500,000. Of this number probably about half are totally incapacitated, while the remainder are able to earn about half of the ordinary wages.[e]

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[a] See Farr, Vital Statistics, London, 1885, pp. 501–514. Harald Westergaard, Mortalität und Morbilität, Jena, 1901, p. 683. See also a pamphlet by Hiram J. Messenger, actuary of the Travelers' Insurance Company, Hartford "The Rate of Sickness;" Pettenkofer, quoted by Uffelman, Handbuch der Hygiene, p. 3. Edwin Chadwick, "The Health of Nations," ed. by B. W. Richardson, 2 vols. (Longmans), London, 1887, Vol. I, p. 57; Mayo-Smith, "Statistics and Sociology," New York, (Macmillan) 1895, p. 158; "Statistische Jahrbuch für das Deutschen Reich, 1908," pp. 304–305.

[b] Judging from the experience of sickness insurance, there is more sickness in the United States than in England. See Dr. Edward Jarvis, "Political Economy of Health," Fifth Report of Mass. Board of Health, 1874. Dr. Jarvis also points out that estimates of illness are based on experience of provident persons among whom illness is a minimum, and that the estimates of illness take no account of chronic ailments or "decreptitude."

[c] Farr, Vital Statistics, p. 513.

[d] Edwin Chadwick, "The Health of Nations," vol. 1, pp. 56–57.

[e] Irving Fisher, "The Cost of Tuberculosis in the United States and Its Reduction," paper read before International Congress on Tuberculosis, Washington, 1908; see also Huber, "Consumption and Civilization," Philadelphia, 1906; and Bardswell, "The Consumptive Workingman," London, 1906.

For every death from typhoid fever, there are about 8 cases of illness, averaging seventy-five days of incapacity. But this is not the only loss. Professor Sedgwick has said, "Hazen's theorem asserts that for every death from typhoid fever avoided by the purification of a polluted public water supply two or three deaths are avoided from other causes. Working under my direction Mr. Scott MacNutt has recently been able to confirm this surprising theorem, and even to establish it as conservative. We have also gone further than Hazen and discovered what the other causes are from which deaths are thus avoided; and, although our results are not yet all published, I may say that conspicuous among these are pneumonia, pulmonary tuberculosis, bronchitis, and infant mortality."[a]

The prevalence of the hook-worm disease in the South has been a matter of investigation for several years by Doctor Stiles[b] of the Public Health and Marine-Hospital Service. The disease is remarkable not so much for its fatality, though that is large, as for the chronic incapacity for work which it produces. For this reason the hook worm has been nicknamed the "germ of laziness." The disease extends over the whole South, and is responsible for a large part both of the sickness (the so-called "laziness") and of the poverty of the "white trash."

There are no satisfactory statistics as to the extent of hook-worm disease; but it has been estimated that the sufferers are incapacitated for labor from one-fourth to one-half of their time. Most striking is the fact that the disease is easily preventable through the introduction of sanitary measures as well as curable by the proper (drug) treatment of the present victims. It has been largely eradicated from Porto Rico.[c] Hook-worm disease weakens when it does not kill and is known to be a precursor of tuberculosis.

Malaria is one of the diseases which are fatal relatively seldom, but which shorten life by predisposing to other causes of death, and narrow life by reducing working efficiency by a large percentage. Doctor Howard states that each year there are probably 3,000,000 cases of malaria in the United States, most of which are in the South. This is practically all preventable.[d]

Dr. Prince A. Morrow says that the number of syphilitics in the United States has been estimated at 2,000,000. This disease is not only in itself a danger, but it also causes a large number of diseases of the circulatory and nervous systems.

Doctor Morrow says that the extermination of social diseases would probably mean the elimination of at least one-half of our institutions for defectives. The loss of citizens to the State from the sterilizing influence of gonorrhea upon the productive energy of the family, and the blighting destructive effect of syphilis upon the offspring are enormous. In the opinion of very competent judges social disease constitutes the most powerful of all factors in the degeneration and depopulation of the world.

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[a] W. T. Sedgwick, "The Call to Public Health," Science, 1908, p. 198.

[b] Report upon the Prevalence and Geographic Distribution of Hook-worm Disease in the United States," Hygienic Laboratory, Bulletin No. 10, February, 1903, Washington.

[c] "Reports of Commission on the Suppression of Uncinariasis, 1904, 1905, 1906-7, 1907-8, San Juan, P. R." This commission has been succeeded by a bureau, the "Anemia dispensary service."

[d] See L. O. Howard, Report to Conservation Commission, "Economic loss to the people of the United States through insects that carry disease."

Among the troops stationed in the Philippines, the venereal morbidity during the year 1904 was 297 per 1,000, largely exceeding the morbidity from malarial fevers and diarrhea; 22 out of every 1,000 soldiers were constantly ineffective from venereal diseases, four times as many as from any other disease.

The statistics of the Navy Department show during the same year, that venereal disease was chargeable with a percentage of 25.2 of the total number of sick days in the hospital from all causes combined. In four years 949 men were discharged from the navy for disability from venereal disease. The statistics of the English army show that among the troops stationed in India 537 per 1,000 were admitted to the hospital for venereal disease. Of the troops returning home to England after completing their time of service in India, 25 per cent were found to be infected with syphilis.

No statistics exist for venereal disease in civil life. It may be more prevalent than in the army and navy service, since the inhibitory influence of military restraint and discipline do not exist and the opportunities for licentious relations are more abundant.

Neisser, a distinguished German authority, states that "fully 75 per cent of the adult male population contract gonorrhea and 15 per cent have syphilis."

What syphilis and gonorrhea represent in the lowered working efficiency of our population—to say nothing of the still more important subject of increased mortality—is impossible to estimate; but it would be difficult to overemphasize the grave danger to national efficiency from these and the other venereal diseases. And here again the most striking point is that the venereal diseases are preventable.

Alcoholism and drug addiction are maladies of frightful prevalence. They are so familiar as to be taken by many as a matter of course.

Venereal diseases and inebriety, whether alcoholic or drug, frequently lead to insanity. Statistics are not yet able to prove conclusively that insanity is increasing, though this is the opinion of the best judges.[a]

Dr. C. L. Dana, formerly president of the New York Academy of Medicine, believes the increase in insanity to be real as well as apparent. He says: "The annual increment of insane in Massachusetts, according to the Massachusetts board of lunacy, is 400 in about 10,000, or 4 per cent." At this ratio the annual increment for the United States would be approximately 5,600. "We may say that in the last twenty-five years the ratio of insane to sane has shown an apparent gradual increase from 1 to 450 to 1 to 300, and this latter seems to be about the ratio in those communities of North America and Europe in which modern conditions of civilization prevail. This average has varied but little in the last few years; the slight yearly increase probably will not change rapidly and probably not continue, for when the increase in the insane reaches a certain point of excess society will have to take notice of it and correct it."[b] There are no accurate figures of the number of insane. Mr. Sanborn estimates that the number exceeds 250,000 in the United States.

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[a] For a critical examination of statistical data on insanity, see Humphreys (Noel, A.), "The alleged increase of insanity," Journal of the Royal Statistical Society, June, 1907.

[b] "Psychiatry in its Relation to Other Sciences," section on psychiatry at the International Congress of Arts and Sciences, St. Louis, September, 1904.

Among defective and disabled classes are to be especially mentioned the feeble-minded, paralytic, crippled, blind, and deaf mutes. The aggregate disability of these groups is greater than is commonly recognized. The preventability is still less appreciated.

With reference to the losses each year from industrial accidents:

The statistical report of the Interstate Commerce Commission for the year ending June 30, 1907, shows that during that year 11,800 persons were killed and 111,000 injured on our American railways, these figures including passengers, employees, and all other persons. A large number of the victims were railway employees, for whose safety Congress has passed a number of laws. The total number of cases of industrial accidents can not be estimated, owing to the lack of statistical information; but Census Bulletin 83 gives the number of deaths by accident and violence in 1900 at 57,500.

"Of 29,000,000 workers in the United States over 500,000 are yearly killed or crippled as a direct result of the occupations in which they are engaged—more than were slain and wounded throughout the whole Russo-Japanese war. More than one-half this tremendous sacrifice of life is needless."[a]

Mr. Frederick L. Hoffman estimates[b] that the number of accidents among men employed in the United States in 1906 was 208,000, of which about 5,000 were fatal. These figures are exclusive of mining, railway, and shipping accidents.

John Mitchell[c] estimates that for every 100,000 tons of coal produced in the United States one mine worker is killed and several injured. In 1907 the figures were 2,500 coal miners killed and 6,000 seriously injured.

In Wisconsin from October 1, 1906, to October 1, 1907, the total number of accidents reported which incapacitated the victim by at least two weeks was 13,572. The accidents to employees constituted 53 per cent of this number.[d]

Special trades have special perils for workmen. "Among diseases to which workmen are most often subject are the so-called 'inanition, scrofula, rachitis, pulmonary consumption, dropsy;' also rheumatic troubles, pleurisy, typhoid fever, gangrene, and the various skin diseases. Every epidemic, be it typhoid, smallpox, scarlet fever, dysentery, cholera, etc., draws its greatest army of victims from this class. For every death that occurs among the richer and higher classes there are many in the working class. It is the workman engaged in unhealthy factories first of all who fills the hospitals and their death chambers."[e]

It is the pollution of the air breathed by workmen, whether the pollution come through poisons or through dust, that makes many trades dangerous. Among poisonous trades are the many lead-using industries, foundries, and chemical factories. Investigations of the dust-producing trades have been made, showing the results on the respiratory systems.

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[a] Ditman, loc. cit., 43.

[b] In an article contributed to the "New Encyclopedia of Social Reform," 1908.

[c] Speech before the Governor's Conference on Conservation, White House, May, 1908.

[d] Thirteenth biennial Report, Bureau of Labor and Industrial Statistics, Madison, Wis., 1908.

[e] C. F. W. Doehring, "Factory Sanitation and Labor Protection," Bulletin Department of Labor No. 44, January, 1903, p. 2.

Hirt's statistics show that men employed in dust-producing occupations suffer much more frequently from pneumonia and consumption than do those not exposed to dust. The relative frequency of these diseases per 100 workmen is as follows:

Cases of consumption and pneumonia per 100 workers in certain occupations.

	Consumption.	Pneumonia.
Workers in metallic dust	28	17.4
Workers in mineral dust	25.2	5.9
Workers in mixed dust	22.6	6.0
Workers in animal dust	20.8	7.7
Workers in vegetable dust	13.3	9.4
Workers in nondusty trades	11.1	[a]4.6

[a] George M. Kober, M. D., "Industrial Hygiene," Bulletin of Bureau of Labor, March, 1908, p. 477.

Mr. Owen R. Lovejoy, secretary of the national child-labor committee, has condensed a table from Indiana reports[a] showing the high injury rate suffered by children in the industries.

Injuries to children in Indiana, 1907.

Proportion of adults injured	5 per 1,000 3 per 1,000
Proportion of children injured	20 per 1,000 10 per 1,000

The injury rate for children is shown to be three to four times as great as for adults.

CHAPTER IV.—*Prevalence of minor ailments.*

SECTION 1.—*Importance of minor ailments.*

The statistics of morbidity which we have given refer to forms which are relatively acute; but there are many milder forms which do not incapacitate the patient from work or compel him to take to his bed. The extent of these milder ills is not generally appreciated. They are often carefully guarded secrets. The individual often knows only his own physical troubles, but is unaware of the fact that almost every person about him has such troubles also. Once you penetrate beneath conventional acquaintance there will almost invariably be found some functional impairment of heart, liver, kidneys or bladder; or dyspepsia, gastritis, jaundice, gallstones, constipation, diarrhea; or insomnia, neurasthenia, nervousness, neuritis, neuralgia, sick headache; or tonsilitis, bronchitis, hay fever, catarrh, grip, colds, sore throat; or rupture, hernia, phlebitis, skin eruption; or rheumatism, lumbago, gout, obesity; or decayed teeth, baldness, deafness, eye ailment, spinal curvature, lameness, broken bones, dislocations, sprains, bruises, cuts, burns, or other "troubles."

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[a] "Eleventh Annual Report of the Department of Inspection of Indiana, 1907," Exhibit C, pp. 166–198.

These so-called "minor ailments" will undoubtedly in the next few years receive much more attention than now. Until recently the physician has been accustomed to treat only acute diseases, but as preventive medicine gradually replaces curative medicine the physician will be more called upon to treat minor ailments. These are generally the first warnings of more serious troubles. If what seem to be "mere colds" were less commonly neglected, tuberculosis would more often be caught in its incipiency, and pneumonia and diphtheria would often be prevented.

From the "common colds" also tonsillitis and abscess of the ear can and do come, purulent inflammations of the pneumatic and venous cavities of the face and skull, and meningitis and cerebral abscess—all of which destroy many lives annually; or the lives may be saved by a surgical operation after a serious and prolonged illness. Tonsilitis, in turn, in addition to lighting up furious inflammations in its own immediate vicinity, can be held responsible in a certain number of cases for serious diseases at a distance from its own site. These are septic arthritis (inflammation of joints), septic peritonitis, appendicitis, endocarditis (valvular disease of the heart)—severe and frequently fatal diseases. Gastritis or gastroenteritis, sick headache, jaundice, lumbago, are not usually of serious import, but sometimes are the signs that point to an underlying cause (alcoholism, overeating, chronic protein intoxication, worry—business or domestic—sedentary life, etc.) which will lead later to arteriosclerosis, chronic nephritis, toxic amblyopia (optic nerve blindness), cirrhosis of the liver, cerebral hemorrhage or valvular disease of the heart.[a]

If the first twinges of rheumatic pains were heeded, gout and the dreaded arthritis deformans would lose most of their terrors. We could then arrest a great majority of serious affections at the very gateway. It can hardly be doubted that even such diseases as cancer, whose causation is not yet understood, gain a foothold through lowered vital resistance, manifesting itself at the first in minor ailments of some kind.

The American neurasthenia, widespread and subtle, has its grip on thousands of men and women, driving them from home and offices annually to sanitaria or various health resorts, and so breaking down their average vitality as to render them much more liable to serious sickness and death.

This, the most widely prevalent of all nervous disorders in this country, seems to be on the increase. It is very commonly found among persons who take no reasonable recreation—many business men, among others—and the loss of time and incapacitation for work are very great, often weeks and months at a time.

As to the extent to which minor ailments exist, no statistics are available. Doctor Castle, of Cincinnati, estimates, from an experience of many years in the medical supervision of institution employees and general practice, that there is an average of at least three days' time lost annually for each person in the population because of such minor ailments. Similarly, Dr. J. F. Morse, of the Battle Creek Sanitarium, who has had a long experience in dealing with a large number of cases, estimates that the average "well man" loses on an average five days a year from work on account of headaches, toothaches, "colds," and similar minor ailments which do not come under the head of any of the diseases reported.

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[a] Letter from Dr. Chas. H. Castle.

SECTION 2.—*Preventability of minor ailments.*

That almost all minor ailments can be avoided is scarcely to be doubted. Doctor Gulick is "inclined to believe that something like nine-tenths of all the minor ailments that we have, and which constitute the chief source of decreasing our daily efficiency, could be removed by careful attention." "With the removal of nine-tenths of our disabilities and the conservation and further development of our natural powers," he adds, "the average person can increase his efficiency 100 per cent, that is, he can be twice as effective. This does not refer to doing merely or mainly twice as much work, of course, but by making less mistakes, and by working at a higher degree of speed when he does work. By working under conditions so that the work does not need to be repeated, the whole total will be much greater—I think not too much to say twice as great—as under ordinary conditions."

Minor ailments are preventable by leading a reasonably hygienic life and by revising the modern gospel of "hustle"—which latter usually means crude, imperfect, and slovenly work, whether mental or manual. The prevention of these diseases would "cost" nothing—for it costs nothing to stay well.

If, again, we consider the experience of those who have made a serious attempt to avoid minor ailments, their preventability becomes clear. Personally, I have known of scores of cases in which the tendency to catch cold has been almost completely overcome. In one case a physician, who as a boy had suffered from continual colds and hay fever, succeeded, through the simplification and control of his diet, in attaining almost complete emancipation, which has lasted over forty years. Another physician reports that for ten years, during which time he has taken special means to produce complete evacuation, he has not caught a single cold. A large number of cases observed are of persons, physicians as well as laymen, who have taken the outdoor cure for tuberculosis or nervous prostration. These persons not only succeeded in combating these serious troubles, but in completely freeing themselves from liability to colds. Evidently, if the outdoor life had been adopted simply as a preventive of colds, it would have prevented originally, as it cured subsequently, their more serious disorders.

CHAPTER V.—*Prevalence of undue fatigue.*

SECTION 1.—*Strength, endurance, and fatigue.*

When a person is free from all specific ailments, both serious and minor, he usually calls himself "well." There is, however, a vast difference between such a "well" man and one in ideally robust health. The difference is one of endurance or susceptibility to fatigue. Many "well" men can not run a block for a street car or climb more than one flight of stairs without feeling completely tired out, while another "well" man will run 25 miles or climb the Matterhorn from pure love of sport. The Swiss guides, throughout the summer season day after day, spend their entire time in climbing. A Chinese cooly will run for hours at a stretch. That the world regards such performances as "marvelous feats of endurance" only shows how marvelously out of training the world as a whole really is. In mental work some persons are unable to apply themselves more than an hour at a time, while others, like Humboldt or Mommsen, can work almost continuously through fifteen hours of the day.

As Mosso[a] and others have proved, muscular fatigue is a chemical effect, due to the circulation of "fatigue poisons" in the blood. This has been strikingly shown by experiments by Weishardt and others on dogs; when blood is transfused from an exhausted dog to a "frisky" one, the latter immediately wilts and becomes fatigued like the former, although he has not exerted himself in the least. In order to reduce fatigue, therefore, we should keep down fatigue poisons. It is not unlikely that almost all poisons produce fatigue, whether the poisons come from infections, from drugs, from impure or excessive food, from bad air, or from exertion.

It should be noted that endurance is a quality quite distinct from strength.[b] Strength is measured by the utmost force a muscle can exert once; endurance by the number of times it can repeat an exertion requiring a specified fraction of available strength at the start. Thus, if each one of two men is barely able to lift a dumb-bell weighing 100 pounds, their strengths are equal, but if one of them can raise a dumb-bell weighing 50 pounds 20 times, while the other can raise it 40 times, the latter may be said to have double the endurance of the former. Another mode of expressing the same thought is that endurance is measured by the slowness with which strength decreases through exertion.

SECTION 2.—*Alcohol and fatigue.*

Of all poisons in ordinary use, alcohol and tobacco are the most common. That alcohol increases fatigue is now commonly recognized by athletes. "Alcohol gives no persistent increase of muscular power. It is well understood by all who control large bodies of men engaged in physical labor that alcohol and effective work are incompatible."[c]

One of the most interesting features of the cycling sport, when long tours were the fashion a few years ago, was the fact that the wayside seller of drinks found himself forced to supply chiefly "temperance drinks." The cyclists discovered that they could not make their "century runs" on alcoholic beverages. Two friends report that they stopped for refreshments and drank beer. Resuming their ride they found it hard to propel the machine, and both imagined some obstruction had lodged in the gears. Only after having dismounted and satisfied themselves to the contrary did they come to the conclusion, whether rightly or wrongly, that the resistance was in their own legs and was due to the beer.

Careful experiments with alcohol in relation to fatigue have been reported by Rivers,[d] who shows that alcohol diminishes the capacity for exertion. Experiments carried on by Professor Aschaffenburg with four typesetters, all users of alcohol, showed that on days when Greek wine, containing 18 per cent of alcohol, was given the men there was considerable diminution of the capacity for work. On the alcohol days two of the men did decidedly less work, while the work of the remaining two was marked by great irregularity.

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[a] See Fatigue, English translation. New York (Putnam), 1904.

[b] See Irving Fisher: The Effect of Diet on Endurance. (Publications of Yale University, Transactions of the Connecticut Academy of Arts and Sciences; New Haven, 1906, p. 1.)

[c] The Liquor Problem, a summary. Report of subcommittee of committee of fifty on physiological aspects of the liquor problem. New York (Houghton-Mifflin), 1905.

[d] W. H. R. Rivers: "Influence of Alcohol on Fatigue, etc." London (Edward Arnold), 1908, pp. 89–90.

The injury from alcohol is mitigated, but not excluded, through combination with sugar, malt, and other beneficial ingredients, as in beer.

SECTION 3.—*Tobacco and fatigue.*

As to tobacco it is a common observation that smoking interferes with one's "wind" in running. The poisons which probably bring about this result include others than nicotine. Possibly the most important poison is carbon monoxide, which has a great affinity for the iron in the blood.[a] When the smoker "inhales," this poison, probably joined with others, enters directly into the blood stream.

In an experiment carried on by Doctor Lombard, "smoking was found to have a very depressing effect upon the strength of the voluntary muscular contractions. * * * Undoubtedly the effect of tobacco to lessen the voluntary power is due to its influence upon the central nervous system."[b]

It is the testimony of many users of tobacco that the habit of smoking leads to nervousness and disinclination to exertion directly after smoking.

Experimentation has shown that smoking increases blood pressure. The greater resistance to circulation offered by the blood is presumably due to the excitation caused by the introduction into the blood stream of foreign matter from the tobacco. There is reason to believe, though the fact has not been established, that endurance is lessened by high blood pressure.

SECTION 4.—*Diet and fatigue.*

Poisons may also enter the system through food. Many poisons come from diseased, contaminated, or adulterated foods; but they may also be due to excess of food or wrong preparation of foods, and especially to the decomposition of protein (the principal ingredient of white of egg and lean meat) in the colon. The absorption of such poisons causes auto-intoxication.

It has long been known by physiologists that the putrefaction in the intestines is the putrefaction of protein. But only recently have they raised the question whether a reduction of the protein element of food would be feasible and whether the resulting reduction in putrefaction and auto-intoxication might not be advantageous.[c] These questions are still under debate, but the trend of physiological opinion is increasingly in favor of protein reduction. Practically this means a lessening of the consumption of lean meat and eggs.

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[a] "The toxicity of tobacco smoke," The Lancet, CLXXV, 1908, p. 104.

[b] Warren P. Lombard, M. D., "Some of the influences which affect the power of voluntary muscular contraction." Journal of Physiology, Vol. XIII, 1892, p. 48.

[c] See C. A. Herter, "Bacterial Infections of the Digestive Tract," New York (Macmillan), 1907.

Evidence has accumulated, though it has not yet been put in proper experimental form for absolute proof, that auto-intoxication is not only an exceedingly common affection, but also the chief cause of undue fatigue. Most persons know the heavy feeling and disinclination to exertion which generally accompany constipation, and, on the other hand, the relief which comes with a complete evacuation.

Leaving auto-intoxication aside, Professor Chittenden is of the opinion that waste products from combustion of protein are probably responsible for fatigue. Whatever the explanation, Professor Chittenden found in his classical experiment[a] with a squad of soldiers, that strength and endurance were increased by a reduction of the protein. Thirteen soldiers were placed for six months on a diet containing a much smaller quantity of protein food than what is prescribed by ordinary dietary standards and containing only one-third of what is demanded by common American usage. Professor Chittenden's results are gaining recognition, but they will need to be further tested before any unanimity of opinion can be reached.

Analysis of the diet of several hundred vegetarians shows that on the whole they are lower in protein than the average American. Comparative experiments on 17 vegetarians and 25 meat eaters in the laboratory of the University of Brussels have shown little differences in strength between the two classes, but a marked superiority of the vegetarians in point of endurance. The average superiority was 53 per cent. The vegetarians recuperated from fatigue more quickly than the meat eaters.[b] To what extent, if at all, the superiority of the vegetarians was due to vegetarianism as such, and to what extent to the fact that they made a more moderate use of protein, can not be exactly determined, although the evidence indicates that the lower protein is the essential factor. The virtues and drawbacks of vegetarianism as such have as yet received almost no scientific study.[c] Professor Chittenden is now engaged in such a study.

In another experiment, comprising 49 subjects and contrasting those on high and low protein diets, it was found that the low protein subjects had greater endurance.[d] For instance, the test of "deep-knee bending" showed that whereas the high-protein subjects could seldom exceed 400 or 500 times, the low-protein men could frequently exceed 1,000, and in one case reached 2,400.

The writer has in his possession several hundred unpublished individual records of men on a low and high protein diet. These, on the whole, seem to show a considerable superiority in endurance among those using the lesser amounts of protein. But while the trend of evidence seems at present to favor a reduction in protein, the question is not yet settled.[e] There exist many conspicuous cases of high protein and great endurance. A striking instance is that of the pedestrian Weston.

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[a] See Russell H. Chittenden, "Physiological Economy in Nutrition," New York (Stokes), 1904, and "The Nutrition of Man," New York (Stokes), 1907.

[b] "Enquete Scientifique sur les Vegeteriens de Bruxelles," par Mlle. le Dr. J. Ioteyko and Mlle. Varia Kipiani, Bruxelles (Lemartin), 1907. For English abstract see "Diet and Endurance at Brussels," Science, Vol. XXVI, 1907, pp. 561–563.

[c] An exception is Caspari, "Physiologische Studien über Vegetarismus," Bonn (Hager), 1905; see also Gautier, "Diet and Dietetics," English translation, London, 1906.

[d] Irving Fisher, "Influence of flesh eating on endurance," Yale Medical Journal, March, 1907.

[e] See, for example, Prof. F. G. Benedict's paper on "The nutritive requirements of the body," American Journal of Physiology, Vol. XVI, 1906, pp. 409–437.

In an experiment on nine healthy students, the writer found that thorough mastication seemed to cause a gradual decrease in protein. The significance of the experiment lay in the improvement in physical endurance of eight of the men, which increased over 90 per cent in five months. The ninth man—the only one whose protein was not greatly reduced—failed to improve in endurance.[a]

SECTION 5.—*Exertion and fatigue.*

Exertion increases combustion of oxygen, and the capacity for exertion is intimately related to the completeness of this combustion.

Experiments in artificially administering oxygen to athletes have been made in England by Hill, Flack, Pombrey, and others.[b] Following these, a series of experiments in swimming recently took place at Huntington, L. I. The swimmers to whom oxygen had been administered surpassed their nonoxygenized competitors as well as their own previous natural records. Doctor Bising, who carried on the experiment, states that the effects of oxygen inhalation are useful for short efforts only. At most the oxygen exercises its influence for not more than three minutes.

Perhaps the most important of the common influences affecting the capacity to resist fatigue is physical exertion. It is well known that a man "in training" has greater endurance than one who attempts exertion without previous systematic exercise or training. In general, it may be said that a person in the "pink of condition" is fit not only for physical but also for mental exertion. The great majority of adults are far from being "in condition," suffering either from lack of exercise or from too much exercise. The ordinary man errs either in one direction or the other. The brain worker lives too sedentary a life, while the manual worker, through fatigue caused by long hours, is in a continual state of overexertion. Could these conditions be remedied, endurance, as measured by capacity to withstand prolonged strains, might be greatly increased.

Experiments have shown that physical endurance can be doubled by dietetic causes alone, or doubled by exercise alone. By both together it is not unlikely that it could be tripled or quadrupled. But when it is said that the endurance, or capacity for exertion, of the ordinary healthy man could be thus multiplied, it is not meant that the hours of his daily work, or even his daily output of work, could be increased in such a ratio. What it does mean is the removal of the fatigue limit, a freer and more buoyant life, and a visible increase in the quantity and quality of work per hour.

In an ideal life fatigue would seldom be experienced. But in most lives, unfortunately, fatigue is a daily experience. A workman who gives intelligent and systematic care to the body writes that when after a long day's work the factory whistle blows at night he, unlike his fellows, feels as fresh as when he began work in the morning. Workmen can by such self-care mitigate some of the evils of

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[a] Irving Fisher, "Effects of diet on endurance," loc. cit.

[b] British Medical Journal, 1908, August 22, p. 499; also August 29, p. 578, Journal of Physiology, 1908, XXXVII, 77–112.

"the long day." But they are amply justified, both in the interest of their own and of national efficiency, in continuing their efforts toward a shortening of the work day.

SECTION 6.—*The working day.*

The present working day is a striking example of the failure to conserve national vitality. In order to keep labor power unimpaired, the working day should be physiological—i. e., it should be such as would enable the average individual to completely recuperate over night. Otherwise, instead of a simple daily cycle, there is a progressive deterioration. A reduction in the length of the work day would be a chief means of improving the vitality of workmen, as well as the worth of life to them.

The fatigue of workmen is largely traceable to their long work day and serves to start a vicious circle. Fatigue puts the workman in an abnormal frame of mind. He seeks to deaden his fatigue by alcohol, tobacco, exciting amusements, and excesses of various kinds. The momentary relief which he thereby obtains is purchased at the expense of an increasing susceptibility to fatigue, resulting sooner or later in complete depletion of his vital energies and in the contraction of tuberculosis or other fatal disease. The decrease in the length of the working day has not diminished the total output.

An instance in which the eight-hour day superseded the nine-hour day with entire success is the case of the Salford Iron Works, of Mather & Platt, at Manchester, England, which changed to the eight-hour day in 1893. As the firm's products were subject to keen competition in both home and foreign markets, it was obliged to look carefully after the labor cost, and its conclusion that such cost did not increase in consequence of the reduction in working hours was reached after extremely accurate comparisons by accountants, who of course took into consideration the saving in consumables, wear and tear, fuel, etc. The Bureau of Labor inquired of Messrs. Mather & Platt if they were still on the eight-hour basis, and received a reply dated May, 24, 1904, in which they stated that—

> our experience since the first year in which it (the eight-hour system) was tried has fully borne out the conclusions then arrived at, and we are fully satisfied that as regards the comparison between eight and nine hours per day the balance of advantages is in favor of the shorter period.[a]
>
> In 1894 the hours of labor of about 43,000 workmen in British government factories and workshops were reduced to forty-eight per week. Of this number, 18,600 received a reduction of five and three-fourths hours a week, and 24,300 had their time reduced two and one-half hours a week. With no change in piece rates the workmen were able to earn as much as formerly. Day workers received an increased hourly rate of pay to make their earnings per week of forty-eight hours equal to those per week of fifty-four hours. It was not found necessary to increase the number of day workers.[b]

In 1899 the owners of the great Zeiss optical goods factory at Jena, Germany, introduced the eight-hour day and then made careful records of the results. In 1903 it was announced that although the aggregate number of hours worked had decreased 15 per cent the output per hour had increased 16.2 per cent.[c]

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[a] New York Labor Bulletin No. 25, June, 1905, p. 240.

[b] Board of Trade Labor Gazette, July, 1905, reported in New York Labor Bulletin No. 28, March, 1906.

[c] New York Labor Bulletin, No. 25, June, 1905, p. 240.

At Liege it was found in a sulphuric acid establishment similar to a foundry[a] that shortening the working day from eleven hours to ten, from ten to nine, and so on gradually down to seven and one-half, resulted, in each case, in an increase of the output.

The Solvay Process Company, of Syracuse, installed in 1892 a system of three eight-hour shifts in place of the two previous shifts of eleven and thirteen hours, respectively. It was stated by the assistant general manager in 1905 that the change had considerably lessened the wear and tear on the men, and that they could be called on to do their work at their highest state of efficiency, which had not been possible on the two-shift basis. President Hazard of the company writes:

> In general, I can say that the results of the change from a twelve-hour shift to an eight-hour shift were very satisfactory and have continued to be so. While the immediate result was to considerably increase the cost per unit of product, the efficiency of the men gradually increased, so that at the end of about one year the first increase has been overcome and the cost per unit of product fell to a point even lower than had been obtained under the twelve-hour shift, and further the time consumed per unit of product has since been so reduced that we are today and for some time have been operating with a smaller number of hours per unit of product than we had under the twelve-hour shift.

Further proof of the benefits of the change to the three-shift day is furnished by the records of the Solvay Mutual Benefit Association for 1891 and 1904. The days lost per man by sickness each year fell from seven and one-half days in 1891 to five and one-half days in 1904.

It is not maintained that in all cases productivity will be as great in eight hours as in nine. Cases to the contrary could also be cited. The point to be insisted upon is not that it is profitable to an employer to make the work day shorter, for often it is not, but to show that it is profitable to the nation and the race. Continual fatigue is inimical to national vitality, and however it may affect the commercial profits of the individual it will in the end deplete the vital resources on which national efficiency depends.

In the interests of this efficiency, a longer time at noon for lunch is usually necessary. The present economy of lunch time is shortsighted, tends to food bolting, indigestion, a drowsy and tired afternoon, and inferior work. This has been shown by actual experience.[b]

The accident bulletins of the Interstate Commerce Commission contain frequent records of disasters caused by the long hours of railway employees. In a recent bulletin, No. 27, two collisions are attributed to the mistakes of employees who have been on duty much longer than the instinct of safety should allow. Collision No. 3,[c] which killed 2 and injured 13, was due to the mistake of a station operator who had been on duty from 7 a. m. to 3.30 p. m. and who had returned to duty at 8 p. m. The collision took place at 12.30 a. m. the next morning.

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[a] See L. G. Fromont, "Une Experience Industrielle de Reduction de la Journel de Travail," Brussels, Solvay Institute, 1906.

[b] See especially description of a French experiment cited by Hubert Higgins in Humaniculture, New York (Stokes), 1906.

[c] Accident Bulletin No. 27, January to March, 1908.

SECTION 7.—*Importance of preventing undue fatigue.*

The economic waste from undue fatigue is probably much greater than the waste from serious illness. We have seen that the average serious illness per capita is usually about two weeks each year. This is about 4 per cent of the year. Expressed differently, about 4 per cent of the population is constantly sick.

On the other hand, the number that suffer partial disability through undue fatigue certainly constitute the great majority of the population. No observer can fail to conclude that this is true of the American working, business, and professional classes, and the latest word among the students of school hygiene is that it is true to a large extent even among children. If therefore we assume that only 50 per cent of the population is suffering some impairment of its best powers through undue fatigue, we are on safe ground. The extent to which the power of this supposed 50 per cent of the population is impaired must certainly exceed 10 per cent. When we consider that young men, supposed to be perfectly well, have the enormous room for improvement indicated in this chapter, and when we consider the gratifying results of experiments with a shorter work day it will be seen that the true impairment is probably several times 10 per cent. Yet if only 50 per cent of the population are suffering an impairment equal to only 10 per cent of its working powers, the result is equivalent to 5 per cent of the population suffering total impairment which is more than the 4 per cent impairment from serious illness.

The relatively slight impairment of efficiency due to overfatigue leads to more serious impairment. Just as minor ailments prove to have an unsuspected importance when considered as gateways to serious illness, so the inefficiency from fatigue is vested with great significance as the first step toward minor ailments. Obviously if overfatigue could be reduced to a minimum, this reduction would carry with it the prevention of the major part of minor ailments, which in turn would lead to a great reduction in more serious illness, and this finally would lead to a great reduction in mortality. A typical succession of events is first fatigue, then colds, then tuberculosis, then death. Prevention, to be effective, must begin at the beginning.

But prevention is merely the first step in increasing the breadth of life. Life is to be broadened not only negatively by diminishing those disabilities which now narrow it, but also positively by increasing the cultivation of vitality. Here we leave the realm of medicine and enter the realm of physical training. The first and lowest step is gymnastics. This is valuable—far more so than the ordinary sedentary man who neglects it realizes—but it is after all a kind of medicine not altogether pleasant to take and far less valuable to him who takes it than are athletic sports, which constitute the next highest stage. Beyond athletic sports in turn comes mental, moral, and spiritual culture, the highest product of health cultivation. It is an encouraging sign of the times that the ecclesiastical view of the Middle Ages, which associated saintliness with sickliness, has given way to modern "muscular Christianity," typified in Young Men's Christian Associations with their gymnastics and athletics. This is but one evidence of the tendency toward the "religion of healthymindedness" described by Professor James. Epictetus taught that no one could be the highest type of philosopher unless in exuberant health. Expressions of Emerson's and Walt Whitman's show how much their spiritual exaltation was bound up with health ideals. "Give me health and a day," said Emerson, "and I will make the pomp of emperors ridiculous." It is only when these health ideals take a deep hold that a nation can achieve its highest state of development. Any country which adopts such ideals as an integral part of its practical life philosophy may be expected to reach or even excel the development of the health-loving Greeks.

The means of securing both the negative prevention of invalidity and the positive accumulation of vitality will form the subject of Part III.

Part III.—METHODS OF CONSERVING LIFE.

CHAPTER VI.—*Conservation through heredity.*

SECTION 1.—*Heredity and environment.*

That the waste of life through preventable disease and death is enormous appears clearly from the facts already cited. The practical problem is this: If such waste is really preventable, what are the conditions necessary to make prevention an accomplished fact? There are two main conditions. First, a general desire for improvement; second, a general knowledge of how to secure that improvement.

Once the general public recognizes the needless waste of vitality, it will not be content until that waste has been eliminated. To such an awakening the American instinct of economy is in itself a powerful spur. Practical men are coming to consider it "good business" to take some care of their own vital resources. As this view gains ground, habits and fashions will adapt themselves to the change. The folly of the man who loses his health in the pursuit of wealth, and then for the rest of his days spends his wealth to win back health, is beginning to be appreciated.

Human vitality depends upon two primary conditions, heredity and hygiene, or conditions preceding birth and conditions during life. In other words, vitality is partly inherited and partly acquired.

It is well known that cultivated plants and animals have been greatly changed and developed by breeding. "The original apple, as offered by nature to mankind, was the small, sour, bitter crab of the forest, unpleasant, indigestible, innutritious. * * * In 1710 Doctor Davenant, a writer on political economy, estimated that the average weight of dressed cattle did not exceed 370 pounds. * * * In 1846 McCullock stated that 'at present the average weight of cattle is estimated at or about 800 pounds.'"[a]

Human heredity is now dependent on haphazard selection. Little attention is paid by those who contemplate marriage to the question of how much stamina will be transmitted to the next generation. The story was told of a famous dog fancier who, when asked why he paid so much attention to his dogs but delegated the care of his children to nurses, replied: "My dogs have a pedigree." Human pedigrees, no less than canine, rest on a physical basis; yet genealogical records of human beings, while they have much to say of social position, have very little to say of physical capacity or intellectual ability. Those who, like Galton and Pearson, believe in a science of eugenics, hope that the day will come when pride of inheritance will include as important, if not as the chief items, physical, mental, and moral stamina. A tendency in this direction can be discerned. When the nobility commanded the reverence of all classes, quite irrespective of ability, commoners, however well endowed by nature, could never obtain the same respect. But to-day the English House of Commons is more honored and respected than the House of Lords.

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[a] See Dr. Edward Jarvis, Political Economy and Health, Fifth Report, Mass. Board of Health, 1874. Doctor Jarvis adds that human life is as "expansible" as animal life.

Once the importance of a physical pedigree comes to be rated at its true value, a man's pride in his own inheritance will show itself in a correlative feeling of responsibility for future generations. For the sake of children yet unborn, men and women will set for themselves physical ideals of the highest order.

SECTION 2.—*Eugenics.*

The whole question of race improvement through heredity constitutes the subject-matter of the new science of eugenics. The devotees of this science are at present engaged in studying the laws of heredity in all its aspects. The Mendelian doctrine of heredity, with the theories of Darwin and Weissman, are some of the topics which need to be studied in reference to their practical application.

Until more results have been obtained, it would be premature to make great claims for the possible future usefulness of applied eugenics. A word may be said to prevent misunderstanding as to its aims. Many have supposed that the object of eugenics was to bring about suitable marriages by compulsion of the Government. Such a proposal would not only be absolutely impracticable, but would defeat the very ends aimed at. Marriage, above all human choices, must, as a rule, be left to the individual, guided by his ideals alone. By the change of these ideals alone can the character of marriages be influenced. Sir Francis Galton, the founder of the science of eugenics, expects intelligent public opinion to be the chief guide in marriage. Just as the union of brother and sister is tabooed, and the marriage of even first cousins[a] is eyed askance—whether justly or not does not matter—so, if the aims of eugenists are carried out, an obviously unhygienic marriage will be frowned upon. It was somewhat in this way that the ancient Sparta raised its vitality to a high point of physical excellence.

Galton has pointed out[b] that present restrictive rules of marriage selection are endured without any sense of loss of privilege or freedom. For example, members of the European nobility are, in their marriage choice, restricted almost wholly to fellow-aristocrats; yet so much has this restriction become a part of their ideal and creed that the narrowness of the range of choice is not usually realized.

Even granting that some marriages are studiously calculated to win money or title, a much stronger or more pervasive, although unconscious, influence is exerted by the ideals which young men and women at marriageable age have formed of what their companions for life should be. Nothing is more certain than that if from childhood they were trained to regard vitality as the first essential in an ideal man or woman, this would influence their personal fancy. Health, beauty, and vitality are natural objects of admiration and love. Titles, wealth, and other extraneous attractions are not. To lessen the public esteem for these, and to increase the esteem for natural human merit, will tend to increase not only the number of healthy marriages, but the importance of the rôle played by normal love. If, therefore, eugenic ideals ever hold sway, love marriages will not only continue to exist, but will become more frequent. Love is a primal and natural instinct, and the more natural men and women are, and the more highly they esteem natural vitality, the more will they be guided by mutual attraction.

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[a] In at least 20 States the marriage of first cousins is forbidden by law. An excellent discussion of this subject is contained in "Consanguineous Marriages in the American Population," by G. B. L. Arner, Ph. D., New York (Longmans), 1908.

[b] "Sociological Papers," London (Macmillan), 1906, Vol. II, p. 12.

If a considerable percentage of the population once shall come to regard vitality as an essential endowment, the effect on mating will be felt in two ways: First, a larger percentage of healthy persons will marry, leaving a larger percentage of unhealthy persons single; second, healthy persons will mate with each other, and unhealthy persons, in so far as they marry at all, will do so among themselves. Of mixed matings there will be a smaller number. Both of these results will tend gradually toward the improvement of the race. That the first—the increased proportion of marriages among the healthy—will do so, is obvious. The second—the marriage of like with like in respect to health—would, it seems probable, operate to increase the number of progeny of healthy couples and decrease that of the unhealthy, especially after the first generation.

Since athletics have come into vogue it is well known that the athletic ideal has led to athletic mating. The tendency of the present devotion to athletics must be to elevate the respect for physical prowess. The high esteem entertained in Japan for physical training and for hygiene as a guarantee of the fighting power of the country, constitutes an object lesson, if not a warning, to Americans who wish their country to be the peer of the best. It would be folly, of course, to expect any change in ideals so complete that there would not be numerous exceptions to hygienic mating, but, once the bulk of mankind are guided by a truer principle in forming marriages, the effect on racial development will make itself distinctly felt within a generation. As President Roosevelt has said: "The preservation of national vigor should be a matter of patriotism." Some persons would even make it a matter of religion.

SECTION 3.—*Eugenics and law.*

It is possible, however, that governmental interference with the birth rate may in future be employed to a limited extent. Two ways have been suggested: One is for the Government to give prizes or bounties to couples that conform to certain specified standards in the same way as the French Government has encouraged the increase of population by offering inducements to couples of the poorer class who raise seven or more children.[a]

The second is to forbid alliances among criminals, paupers, and the feeble-minded. These classes fall under the tutelage of the State, and thereby forfeit their right to free choice. Already Indiana,[a] Connecticut,[b] Michigan,[c] and other States in this country, have passed laws of this sort.

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[a] In 1889, fathers of seven children were made exempt from payment of the personal property tax. This exemption was in 1890 limited to fathers who paid taxes of not over 10 francs each.

Indiana extends the prohibition to all persons suffering from transmissible disease of any sort. This prohibition is called into daily operation in that State. It is in the power of the Indiana state board of health to raise by degrees the standards of health demanded of those who desire license to marry, a provision that aims directly at the improvement of human vitality in the State. Indiana has gone even further and has recently provided[d] that confirmed criminals, imbeciles, idiots, and rapists, procreation by whom is deemed inadvisable by experts, shall be unsexed (or "sterilized") by surgical operation. Under this law over 800 prisoners have been sterilized to date.[e]

The experiments started in Indiana and other States will be interesting to watch, and promise an improvement over the conditions which have prevailed too often in the past. Professor Brewer, of Yale, tells of a case in Connecticut some years ago where a feeble-minded pauper woman, kept as a public ward, was admired by a half-witted farmer living in an adjoining town. A selectman of the town maintaining the woman "to get rid of her support" encouraged their marriage. His short-sightedness, even from the standpoint of immediate money economy, to say nothing of racial economy, became apparent when, a few years later, she and her husband and three idiotic children drifted into the poorhouse of the husband's town.

That laws like the ones discussed, but of gradually increasing severity, will become common in the future seems likely; and, as Professor Lankester has remarked, humanity will probably submit in the future to communal restriction of the right to multiply with as good grace as it has given up the right to rob and to rape.[f]

The effect of restrictions upon free right of marriage is discussed by Doctor Hurty, secretary of the Indiana state board of health, as follows:

> It seems most essential and necessary that we have laws for the prevention of the production of the unfit if society is to be saved from destruction. Modern hygiene, under which I include in this instance all such benevolent institutions as insane asylums and institutions for the feeble-minded, is extending the duration of life of the dependents and deficients, and it might be added that the humane and hygienic care in the prisons is extending the duration of life of the delinquents. In Indiana the life duration of the insane has been extended eight years within the last two decades. This slight extension means a very considerable burden upon the people, and if this class of deficients is unrestricted we can readily see what a burden time will place upon society. The production of the unfit must cease if charity and hygiene continue. Otherwise it seems certain that society will be swamped.

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[a] Indiana Laws of 1905, chap. 126, H. 118, sec. 3.

[b] Connecticut Statutes (revision of 1902, sec. 1354), forbid the marriage of epileptics.

[c] Michigan forbids the marriage of epileptics.

[d] Indiana Law of 1907, chap. 215, H. 364.

[e] Letter from Dr. J. N. Hurty.

[f] E. R. Lankester, "The Kingdom of Man," London (Constable), 1907, p. 41. The recent report of the Royal Commission on the Care and Control of the Feeble Minded recommends such restriction.

While institutional treatment of the insane is right and proper from a humanitarian point of view, by bringing an increase in the average insane lifetime it adds to the public burden and enlarges the figures of the living insane. Mr. Sanborn estimates the average insane life in Massachusetts at thirteen years, of which at least three years occur, on the average, before hospital treatment is applied. He adds:

> I suspect we have come nearer to statistical accuracy on this question in Massachusetts than has been reached in any region of equal population anywhere. The world has been gradually coming round to the conclusions reached by the late Dr. Pliny Earle (of Northampton) and myself, viz, that the changes in the social and sanitary conditions of all civilized countries have increased the number (proportioned to population) of new cases of insanity, while the improved treatment of patients in the meantime has made the average insane life longer than formerly, and that in spite of the well-known increase in forms, like paresis and epilepsy, which may soon end fatally.

Interesting records exist of two families of criminals, the so-called "Jukes" and the "Tribe of Ishmael." From the one man who founded the "Juke" family came 1,200 descendants in seventy-five years; out of these, 310 were professional paupers, who spent an aggregate of two thousand three hundred years in poorhouses, 50 were prostitutes, 7 murderers, 60 habitual thieves, and 130 common criminals.

Dugdale[a] has estimated that the "Juke" family was an economic loss to the State, measured in terms of potential usefulness wasted, costs of prosecution, expenses of maintenance in jail, hospital, and asylums, and of private loss through thefts and robberies of $1,300,000 in seventy-five years, or over $1,000 for each member of the family.

Similarly, the "Tribe of Ishmael," numbering 1,692 individuals in six generations, has produced 121 known prostitutes and has bred hundreds of petty thieves, vagrants, and murderers. The history of the tribe is a swiftly moving picture of social degeneration and gross parasitism, extending from its seventeenth-century convict ancestry to the present-day horde of wandering and criminal descendants.[b]

Had the original criminals in the "Juke" family and the "Tribe of Ishmael" been sterilized under some law like that of Indiana, this country would not only have been spared a widely disseminated criminal, epileptic, and immoral strain, but would have saved hundreds of thousands of dollars paid out for criminal suits and for institutional care, to say nothing of the expenses still to come from the incapacity and criminality of future generations.

These cases present only one side of the case. Over against them may be set illustrious families in which great intellectual ability and moral worth have been passed on through many generations. Such a one is the Hohenzollern family. In commenting on the frequent occurrence of persons of surpassing mental and moral attainments in this family, Woods[c] says: "It is particularly suggestive of what might be done with the human race were mankind ever so inclined." A similar example from a different walk in life is afforded by the Darwin family, where for four generations in direct line (Erasmus, Charles,

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[a] R. L. Dugdale: "The Jukes," New York (Putnam), 1877.

[b] Oscar C. McCulloch, "The Tribe of Ishmael," a study in social degeneration, "Report of Fifteenth Annual Conference of Charities and Corrections, 1888," pp. 154–159.

[c] F. A. Woods, "Mental and Moral Heredity," New York (Holt), p. 79.

George, Horace, and Francis) as well as in collateral lines (e. g., Frances Galton) scientific ability of the first rank has been manifest.[a]

President Roosevelt has pointed out that "race suicide" is a sign and accompaniment of coming decay. Mere numerical increase is not the whole solution, however; there must be improvement in quality also. A race that can not hold its fiber strong and true deserves to suffer extinction through race suicide. The decline of our Puritan stock, so well pictured in the genteel but worn-out Pyncheon family of Hawthorne's novel, need not alarm us if we can replace it with a new influx from the West or from the vigorous stocks of Europe.

There is one problem which concerns both the numbers and the quality of future generations, which hitherto has received practically no attention except in a partial report upon the subject in Australia. This problem is, What is now and will be the effect of voluntary childlessness upon the size and character of the birth rate and upon morals? It would be useless, here, however, to do more than mention this as one of the gravest problems in the world to-day. Ronald M. Byrnes[b] shows that the fecundity of Yale graduates has steadily diminished from 5.7 for the graduates of 1701–1791 to 2.0 for those of 1867–1886. This reduction is much greater than the reduction for the whole country, which is reported by the census to be from 5.8 in 1790 to 4.6 in 1900. Degenerates have large families. From a study of 150 degenerate families, Doctor Tredgold[c] found that the average number of children per family was 7.3, while the normal average for the country at large (England) is 4. These figures do not specify the frequency of marriage among degenerates or the mortality. Unless the one is sufficiently low and the other sufficiently high, there must follow deterioration. General reduction of the birth rate may end in depopulation. It is not unlikely that this phenomenon will be the stimulus needed to bring about practical eugenic reforms.

What eugenics might possibly accomplish is indicated by one writer in the following manner: "How rapidly the race would advance if mankind should resolve: 'The next generation must be born with healthy bodies; must be nurtured in healthy physical and moral environments; and must be filled with the ambition to again give birth to a still healthier, still nobler, generation.' "[d]

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[a] The Frances Galton Laboratory for National Eugenics, University of London, is soon to issue a "Treasury of Human Inheritance," containing pedigrees illustrating inheritance of various types of intellectual ability, of tuberculous stocks, of epilepsy, physical depravity, etc.

[b] Yale Review, November, 1908.

[c] W. C. D. Whetham, "Inheritance and Sociology," the Nineteenth Century, January, 1909.

[d] Louis R. Ehrich, "Posteritism," an address delivered at the dedication exercises of The Century Chest, Colorado Springs, Colo., 1901. For literature on eugenics, the reader is referred to the following papers and the references therein contained: "Eugenics, Its Definition, Scope, and Aims," by Francis Galton, American Journal of Sociology, Vol. X, pp. 1–6, 1904. "The Scope and Importance to the State of the Science of National Eugenics," by Karl Pearson, Oxford University Press, England. "Social Darwinism," by D. Collin Wells, Papers and Proceedings of the American Sociological Society, Vol. I, University of Chicago Press. "The Human Harvest," by David Starr Jordan, Boston (American Unitarian Association), 1907. "Eugenics," by Prof. Albert G. Keller, Yale Review, August, 1908. "A First Study of the Statistics of Pulmonary Tuberculosis," by Karl Pearson, Drapers Company, Research Memoirs, London (Delau & Co.), 1907.

CHAPTER VII.—*Conservation through public hygiene.*

SECTION 1.—*Municipal hygiene.*

Whatever improvements in heredity may sometime be achieved, the benefits of their influence can be enjoyed only by future, perhaps distantly future, generations. We of the present generation have to take our heredity as we find it. We can not follow the advice of the humorous philosopher to begin life by selecting our grandparents; but, through hygiene, we can make the most of our inherited endowment. Even such a limited effort offers large—amazingly large—rewards.

Ideal conditions for health comprise a pure and disease-free atmosphere in which to live and work; pure food and a pure water supply; protection from infection and accident; and a proper adjustment of work, rest, and amusement. Existing conditions are not only far from ideal, but also far from what might easily and speedily be attained.

That the saving power of hygiene is great is now universally recognized; that it will be greater is the hope and belief of those most competent to judge. "If hygiene were able to prolong life when it was little developed, as was the case until recently, we may well believe that, with our greater knowledge of to-day, a much better result will be obtained."[a]

There is every reason to believe that human beings are as amenable to cultivation as other animals and plants. Professor Graves, of the Yale Forest School, states that by protecting trees from infection their lives may often be prolonged a century. Domestic animals are equally dependent on care. Doctor McGee states that the growth of a colt may be stopped by giving it alcohol.

The methods of securing improvement in health conditions may be roughly classified under three groups: Public hygiene, semipublic hygiene, and personal hygiene. The first group refers to activities of the government; the second refers to activities of the medical profession and institutions such as hospitals, sanatoria, schools, and factories, and to voluntary associations; the third group deals with the private life of the family and the individual. Each of these three groups covers phases of all three branches of hygiene, viz, the hygiene of environment, nutrition, and activity.[b]

In this chapter we have to deal with public or governmental hygiene. This branch has been chiefly concerned with pure air and pure food and with organisms producing epidemic diseases. Boards of health are a recent invention, and in this country they have as yet been only imperfectly developed. They can never become the power they should be until, first, public opinion better realizes their usefulness and the fact that their cost to the taxpayer is saved many times over by the prevention of death and disease; second, more and better health legislation is enacted—national, state, and municipal; and, third, special training is secured for what is really a new profession, that of public health officer—a profession already recognized in England by a special diploma.

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[a] Metchnikoff, Prolongation of Life, p. 144.

[b] Since this report was written there has appeared the excellent and inspiring "Civics and Health," by William H. Allen, Bureau of Municipal Research, New York (Ginn), 1909.

The health officer should be supported entirely by the salary of his office and should be absolutely prohibited from practicing medicine. Not only are his duties incompatible with practice quite as much as those of judges with the practice of law, but if he gives them proper attention there is no time for other duties. No court, police, or fire department, or other agency of government, can be more important to a people than this under the complex conditions incident to the rapid growth of both rural and urban populations. It is so important that this be realized that it is worthy of serious consideration as to whether it would not be better for all imperfectly equipped and supported health boards in this country to resign—so that the authorities and people would be brought face to face with the knowledge that they have no real protection except in the emergency of an epidemic—than for existing conditions to continue.

Laboratories, research workers, statisticians, and other facilities for the performance of a national board of health's duties should be furnished in proportion to the power and wealth of the Government and the vast interests it would protect and promote. The results of its scientific and collective investigations should be constantly utilized in promoting health in the army and navy, in protecting streams and soils from pollution, in the construction of interstate waterways, in the reclamation of swamp lands, and in other public works involving health problems of supreme importance to the future of this country.[a]

Public hygiene may be studied under three heads, corresponding to our governmental divisions: Municipal hygiene, state hygiene, and federal hygiene.

Municipal hygiene and sanitation are placed largely in the hands of city boards of health, or equivalent organizations, which have power to issue sanitary regulations, abate nuisances, and even to punish infractions of their instructions by fine and imprisonment. Sanitary legislation is a product of advanced civilization. To-day not a city is without a board of health. The powers of these boards have grown, till to-day they are by no means inconsiderable; yet they must be given even greater authority, if our municipal sanitary conditions are to be what they should. Public apathy and political interference are such that health authorities can not enforce their orders. In addition to the acquirement of greater power, city health boards often need purification of motive and the banishment of political bickerings and personal jealousies.

The simplest ordinances along the line of public hygiene are those against spitting, which now remain so largely unenforced.

The smoke nuisance is another seemingly simple form of air vitiation that is receiving attention to-day. Sulphuric acid is apparently the most injurious factor. The corrosion of stone structures suggests the irritation resulting in catarrh and other respiratory mucous-membrane troubles.[b]

The effect of the introduction of closed sewers on the reduction of tuberculosis should not be overlooked. By closing sewers, impure gases have been confined, thereby removing an important source of air pollution. Some cities realize that pure air spells life and health to its inhabitants, and that pure air is a possibility only when atmospheric particles of soot and dirt are removed.

Regulations governing garbage removal, notification and isolation of disease, and the like are as a rule enforced, and new regulations are being issued constantly. Substantial progress is shown each year in the purification of city water supplies, in the improvement of sewage disposal, and in the bettering of drainage conditions. Streets are more thoroughly cleaned and the elimination of public and private nuisances continues without ceasing.

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[a] Letter from Dr. J. N. McCormack.

[b] See Journal American Medical Association, September 7, 1907, p. 813.

Our city streets have received greater care since Colonel Waring organized his "white wings" brigade in New York City a dozen years ago, thus proving the great effectiveness of clean streets in the elimination of disease. The probable elimination of the horse from our city life, through automobiles, the betterment of our trolley systems, and the introduction of subways (especially freight subways) will go far to improve our city atmosphere. The problem of city air will be half solved when our streets reach their proper state of cleanliness. The gradual elimination of the horse will tend not only to produce cleaner air, but also to reduce the dangers from flies. It is in horse manure that the common horsefly ("typhoid fly") chiefly breeds. Doctor Howard attributes the termination of typhoid in certain parts of Washington to the displacement of the horse by the automobile.

Only within a dozen years has the dread importance of insect carriers of disease been realized. That mosquitoes carry malarial germs; that flies are the propagators of typhoid, cholera, and other infectious diseases; that rats breed the fleas which transmit to man the dreaded Asiatic plague [a]—all this knowledge is of recent origin.[b]

Well people are sometimes carriers and distribute typhoid, diphtheria, etc., a fact which complicates public-health regulations.

The simple reporting of all contagious disease to the health authorities immediately on its appearance is often the means of preventing an epidemic.

Smallpox epidemics are prevented both by quarantine and vaccination. Because of the outcry against compulsory vaccination, in some places the responsibility for vaccination is being thrown upon the individual. This is true in Leicester, England, and in Minnesota. Doctor Bracken, secretary of the Minnesota State Board of Health, writes that since the quarantine has been abandoned and the individual has had the option of being vaccinated or not, a larger number has been vaccinated and smallpox has diminished.

We are awaking to the importance of securing for ourselves, through our city health agencies, a pure milk supply. Great danger is also present in cream, butter, cheese, and ice cream. More than one city has inaugurated a policy of careful supervision of the milk supply. Montclair, N. J., has a well-considered plan in operation whereby the bacterial count of each dairy is public to inquirers at the board of health. This species of publicity will some day prove a strong incentive to a better milk supply. Some cities have even established municipal stations, where during the summer season sanitary milk may be purchased at cost. Doctor Goler, of Rochester, has emphasized the fact that "We employ physicians to cure children affected by the diarrheal diseases from dirty milk, while we permit the sale of dirty milk from filthy cattle."[a]

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[a] See Rupert Blue, "The prophylaxis and eradication of plague," California State Journal of Medicine, Vol. V, 1907, p. 304.

[b] A full treatment of the subject of insect-borne disease has been prepared by Dr. L. O. Howard, Chief of the Bureau of Entomology of the Department of Agriculture, for the National Conservation Commission. See also Charles Harrington, M. D., "Practical Hygiene," Third Edition, Philadelphia, (Lea), 1905, pp. 637-660.

In Rochester, through the efforts of Doctors Goler and Roby, a few municipal milk stations were established in 1897, where during July and August milk in nursing bottles could be bought at a low price. The reduction in the Rochester infant death rate between 1897 and 1906 is doubtless due to many other conditions than the quality of milk; but the special attention drawn to the milk supply and the consequent education of the public, which probably boiled its milk when it could not get it clean, would explain a considerable part of the reduction.[b]

The interrelation of the purity of milk supply and infant mortality is shown by the following excerpt from Doctor Woodward's annual report as health officer of the District of Columbia for the year 1907:

> High as is the infantile mortality even now from diarrhea and inflammation of the bowels, it is far below the figures that formerly prevailed.
>
> The only explanation for the fall in the death rate from infantile diarrhea that I have been able to discover is the enactment on March 2, 1895, of the law regulating the sale of milk in this District and the establishment of dairy and dairy-farm inspection under the provision of that law.

The weekly report of the Cincinnati board of health for August 21, 1908, states:

> As far as we know, there has been but one death among the babies whose food supply has been obtained from the milk stations. When it is taken into consideration the large number of children we have supplied, this statement is certainly a fitting commentary upon the value of a bacteria-free and chemically pure milk.

At the recent International Congress on Tuberculosis, one delegate reported an experiment in England which has not yet appeared in print. In Liverpool the local government board tried the experiment of using pasteurized milk. The amount of illness and death in that city from children's tuberculosis is very great, yet among 1,800 children who were given pasteurized milk and who were carefully watched every week not a single case of tuberculosis developed, which seems to prove conclusively that children's tuberculosis is entirely preventable by the use of pure or pasteurized milk. This is interesting, though at variance with former opinion regarding bovine tuberculosis in children.

In this section should also be mentioned such municipal health agencies as public baths, bacteriological laboratories, and the distribution and administration of specific antitoxin, vaccine, and free medical service. Municipal inspection of local abbatoirs is also important, inasmuch as federal inspection covers only establishments engaged in interstate business.

Most important of all is the matter of preventing pollution of the water supply of cities, a topic that will receive fuller treatment later in the chapter.

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[a] See George W. Goler, M. D., "Municipal regulations of the milk supply," paper at the meeting of the American Medical Association, 1907, p. 2. For conclusions based on a study of 330 milk-borne epidemics, see George M. Kober, M. D., "Milk in relation to public health," S. Doc. No. 441, Government Printing Office, 1902.

[b] See George W. Goler, M. D., "Origin, development, and results of municipal milk work in Rochester, N. Y.," Maryland Medical Journal, June, 1906.

The needs of municipal as of state hygiene are not so much new laws as better men to enforce existing laws and an aroused public opinion that will result in the appropriation of funds sufficient to enable health authorities to perform their duties in an efficient manner. Larger appropriations will doubtless bring better men into the public-health service.

SECTION 2.—*State hygiene.*

State hygiene is necessary to supplement municipal hygiene for many reasons. One is that the country often has no other sort of sanitation possible. Another is that the city is dependent on the country for its water, milk, and other supplies. Dr. W. G. Daggett, of New Haven, has emphasized the fact that in origin typhoid is largely a rural disease and must be combated by controlling rural privies and other sources of infection.[a] A competent authority asserts that "old country wells, so much valued by their owners, are a positive menace to public health. Fully 50 per cent of these are unfit for use." Much of the typhoid fever brought by milk is readily traceable to such wells.

In the control of the liquor traffic the State and local units should cooperate.[b]

A state, rather than a municipal, function is the regulation of woman labor and child labor. The growth of public opinion on this point has been rapid. In order to make the working hours meet the physiological requirements of women, two special conditions should be attended to. One is her monthly period; the other is childbearing. The neglect of both is responsible not only for physical impairment of factory women, but also for their inability to perform their functions as mothers of the race. Doctor Stiles, of the Public Health and Marine-Hospital Service, has suggested a very sensible remedy to meet the first of these conditions, and one which has met with the approval of many factory employers. It is that each woman shall have the right, once every month, to walk out of the factory without any questions being asked, and without loss of the day's wages. The matter is further simplified in factories provided with a matron and a rest room. In respect to the second condition—that of childbearing—the evidence is clear and convincing. Women, on account of their imperfectly developed muscular system and more delicate physique, are unfitted for hard work; nor should they be obliged to work steadily in a sedentary position, especially at the sewing machine, or other occupations involving the use of the lower extremities. Special protection should be extended to them during the childbearing period. It is a matter of constant observation that women who have to deny themselves proper rest and care during the next six weeks after confinement are very liable to suffer from hemorrhages and chronic uterine diseases, while miscarriages and premature births are not infrequent results of overwork.[c]

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[a] "The prevention of typhoid fever," Proceedings Connecticut Medical Society, New Haven.

[b] See "Regulation of the liquor traffic," Annals American Academy of Political and Social Science, November, 1908.

[c] George M. Kober, M. D., "Industrial and personal hygiene," "Report of Committee on Social Betterment of the President's Homes Commission," Washington, 1908, pp. 67–68.

The employment of mothers shortly before and after the time of childbirth is prohibited in a number of European countries. American statutes, however, are almost silent on the question.[a] Professor Jevons went so far as to advocate the enactment of legislation forbidding the employment of mothers till their youngest children were at least 3 years old.

The beneficial effect on the mother, and especially on the child, of forbidding the factory to her just before and after childbirth has been proved many times. The case of M. Dollfus, a large employer of women at Mulhausen, in Alsace, has been repeatedly cited. He required mothers to remain away from their work for a period of six weeks after childbirth, during which time he paid them full wages. The decrease in infantile mortality in the first year of the experiment was from more than 40 to less than 18 per cent.[b]

The waste of vitality from unphysiological hours of work is most striking in the case of children. It is hardly to be questioned that children need longer hours of rest and sleep than adults, and that their immature bodies are much closer to the fatigue limit. A little girl in a southern mill replied to Mrs. Van Vorst's query whether she were often tired, "Why, I'm always tired." Except in unusual cases and for limited periods, child factory labor can not be defended on any hygienic grounds. The period of preparation for a wholesome, healthy life should be left free from the cares and evil physical influences of factory life. No child should run the risk of serious accident, deformity, dwarfing, or mental stunting through factory labor. It is true that in the South child labor is often the lesser of two evils, the other being the life on a farm where, through soil pollution, the child contracts hook-worm disease. Here the abolition of child labor should be preceded by the abolition of hook-worm disease.[c]

Closely connected with the restriction of child and woman labor is factory legislation in general, dealing with hours of labor, factory hygiene and sanitation, and dangers from industrial accident.

The hours of labor have for a century been on a gradual decrease. A hundred years ago fourteen and fifteen hours were by no means uncommon. The first public action regarding hours of labor was taken by President Van Buren in 1840, when he set ten hours as the limit of the working day in all government establishments. Thirty years later this was lowered by Congress to eight hours. Since 1850 the fight has been waged for a shorter day, both by labor unions and individuals; and the statutes of nearly all States contain legislation limiting the working hours of women and children in all industries, as well as of all workers in certain industries, especially mining, railroading, and the more dangerous manufacturing industries. The Aldrich report of 1890[d] estimated that the American working day averaged eleven and four-tenths hours in 1840 and ten hours in 1890. Tables based upon annual reports of the Bureau of Labor show a reduction of about 4 per cent from 1890 to 1903,[e] while it is the opinion of United States Commissioner of Labor Neill that the figures for 1908 would unquestionably be lower than for 1903, as the struggle for the shorter working day has been making steady progress each year.[a]

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[a] John Spargo, "The Bitter Cry of the Children," New York (Macmillan), 1906, pp. 44–45.

[b] Spargo, loc. cit., pp. 50–51.

[c] See "Report of the Surgeon-General of the Public Health and Marine-Hospital Service for 1907," relating to the investigations of Doctor Stiles.

[d] "Report on Wholesale Prices and Wages," 1890, Vol. I, p. 178.

[e] T. S. Adams and Helen L. Sumner, "Labor Problems," New York (Macmillan), 1905, pp. 516–518.

The frightful losses of life and efficiency from preventable accidents can be prevented only by state legislation.[b]

Our employer's liability acts are very unsatisfactory, because they fix no scale of compensation for injuries, but necessitate expensive lawsuits to determine in each case the sum due. A president of an insurance company doing a large business in employer's liability insurance states that of the sums they pay employers only one-quarter reaches the injured employee, who is forced to spend the other three-fourths in litigation. In England the workman's compensation acts have substituted a system of specific sums for which the employer is liable. Not only does this result in larger indemnities reaching the injured, because suits are ordinarily unnecessary, but it has the further beneficial effect of reducing the number of accidents by inducing employers to instal safety devices.

The regulation not only of the place of work, but also of the dwelling place, has come to demand action on the part of the State as well as of the community. The growth in tenement-house legislation during the past ten years has been most encouraging. Standards of sanitation for our large buildings have been raised; provision is increasingly made for good light, air, water, and for protection from fire; and the "rookeries" of old are giving way to improved tenements. Yet New York City still contains 300,000 rooms without a window.[c]

SECTION 3.—*Federal hygiene.*

The regulation of disease has increasingly become a national function. The exclusion of immigrants with infectious diseases is only one instance of this; another is the work of our Public Health and Marine-Hospital Service, which not only regulates the spread of disease from State to State, and regulates by quarantine the entry of disease from without the country, but also assists local health boards in their fights against epidemics and disease scourges. Epecially is this true in coastal cities. The Marine-Hospital Service assisted New Orleans to eliminate yellow fever and San Francisco to rid itself of bubonic plague. In addition, this service treats 50,000 seamen of the merchant marine each year, conducts a large number of hospitals and relief stations, examines pilots, life-saving crews and revenue-service men, and conducts a well-equipped hygienic laboratory.

Federal, state, and municipal sanitation are all concerned with the hygiene of transportation. To-day almost the whole American public travels, and it is therefore most important that the conveyances which they occupy, whether carriage, cab, street car, or railway train, shall be sanitary in respect to ventilation, cleanliness, toilet facilities, spittoons, dust, smoke, sleeping-car accommodations, and the like. In smoking cars, in addition to the smoke itself, the floors are usually befouled with tobacco juice and other expectoration. The efficient remedy here as elsewhere is to be found, not simply in providing facilities for cleanliness, but in fostering the present public sentiment against spitting and other untidy habits. A physician of experience maintains the opinion that "foul air in railway trains and street cars is the cause of serious poisonings called 'colds' and 'grip,' particularly in those many trains where air from the smoker sweeps through passenger cars."

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[a] See Bulletin of the Bureau of Labor, No. 77, July, 1908, pp. 6–7; also, "First Annual Report on Changes in Rates of Wages and Hours of Labor in Massachusetts," Boston, 1908, pp. 592–3.

[b] The Federal Government can of course reach interstate railways. A law passed during the last session provided for a safe locomotive ash pan. Previous laws provide for automatic couplers, air brakes, etc.

[c] A. Jacobi, M. D., "The physical cost of women's work," Charities, February 2, 1907.

The development of our national quarantine methods is indicated in the following paragraph from Surgeon-General Wyman, of the Public Health and Marine-Hospital Service:

> Until 1893 there was, properly speaking, no national system of quarantine. The colonies had their own quarantine regulations before the formation of the Union, and from that event to 1893 quarantine was left to the care of state governments and by the latter to county governments or to municipalities, as the case might be. There was, indeed, national legislation, but all the acts of Congress up to 1893 relating to quarantine specially provided that the said national measures were in aid of the state and local authorities. Whatever opinions may have been held by members of the national legislature, quarantine was permitted to be exercised by the States as a police function, and even in the present law, which gives national supremacy, it is provided that assistance shall be given the States or municipalities by the government authorities, the supremacy of the latter being asserted only when the state or local authorities fail or refuse to enforce the uniform national regulations.[a]

To-day efficient inspection at our various ports of entry and at disembarking stations abroad keeps out many cases of disease each year, while the quarantine cordon thrown around ports or municipal quarters affected by infectious disease is an important factor in stamping out such disease.

Federal meat inspection chiefly benefits the foreigner, but the administration of the pure-food laws is of value to our own people.

There are two functions of Federal Government which now are very imperfectly served and which might be made of paramount importance. They are the functions of research and of the dissemination of information. A poultry raiser, or a cattleman, or a farmer can secure scientific information to guide him in his selections of fowl, or stock, or seed by applying to the Government at Washington, but information on how to raise children has up to this time been neglected by our Government. Nothing is to-day more significant of future progress than the fact that the President, the President-elect, and many Congressmen are so strongly in favor of a greater federal organization of health. Through the dissemination of information throughout the country, through enactment and administration of effective regulations concerning pure food, inspection of meat, and exclusion of foreign diseases, through research, statistics, and through better standards for state and municipal health service, a great economy of national vitality can be effected. Washington, our national capital, might be made by the Federal Government a model city of healthfulness, as a preliminary to its becoming a model in every other way.

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[a] Walter Wyman, M. D., "The quarantine system of the United States," The Sanitarian, November, 1897, p. 3. See also James W. Garner, "Federal activity in the interest of the public health," Yale Review, 1905–6, p. 181.

Army hygiene in time of war is most important. The lack of such hygiene has shown grave consequences. In the Boer war the British army in South Africa lost more men from typhoid fever than from wounds received in battle.[a]

The efficiency of Japanese hygiene manifests itself in the fact that General Oku's army of 75,000 during the recent Russo-Japanese war had but 187 typhoid fever cases in a seven months' active campaign.

The Japanese reduced their dysentery cases from 12,052 in the Chinese war to 6,624 in the Russian war; their cholera cases from 7,667 to none; and their malaria cases from 41,734 to 1,257. This was in spite of the fact that their army in the Russian war was three times the size of that employed in the Chinese war.[b]

The crying need of better statistics is trenchantly expressed by Dr. Cressy L. Wilbur, Chief of the Division of Vital Statistics of the Census Bureau, whose words should be read and pondered by everyone who desires to see any intelligent conservation of our vital resources:

> Sound vital statistics are the indispensable basis of modern sanitation. A nation that does not consider it necessary, or that is not able, to provide adequate means for registering the births of its own children, or for officially recording the deaths of its citizens, can hardly be supposed to attach sufficient value to human life to enable sanitary measures for its conservation to be adequately carried out.
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> For the continental United States in 1907 somewhat less than one-half of the total population (48.8 per cent) was represented in the registration area from which returns of deaths were received by the Bureau of the Census. For the remaining 51.2 per cent of the total population of the United States, estimated at 43,774,724 persons, either very imperfect laws were in effect, giving only partial registration, quite worthless for statistical purposes, or else the conditions in many States might be represented by the statement made by one of their health officers, that it buries its dead people with no more ceremony than it buries its dead dogs.
>
> As for the registration of births, a measure which is so supremely important for the knowledge of infant mortality, for the protection of infant life, and for securing the legal rights of children, not a single State in the Union nor a single city of any considerable size makes positive claim that it registers as many as nine births out of every ten that occur. Even the city of Washington, whose law for this purpose is a direct enactment of Congress, does not arise above this low limit of efficiency. The total number of births must be known before one can make a computation of infant mortality which will be comparable with the rates given in the vital statistics of all civilized nations except the United States. This ratio depends upon the comparison of deaths of infants under 1 year of age with total births, and, as we have no exact registration of births, we can not present these important statistics.
>
> In the consideration of the effect of such an important disease as tuberculosis upon the people of the United States there is no means of knowing, within a very wide margin of error, exactly how many persons die from this cause in this country during any year. We have registration of deaths for about one-half of the population only, and the very dissimilar conditions of life and the large proportion of colored population in the unregistered half seriously interfere with any attempts to guess at the exact number. Estimates have varied from 138,000 to 200,000. The truth probably lies somewhere between them, but we certainly ought to have an exact record of the facts and not be obliged to depend upon mere guesswork in entering upon an important sanitary undertaking, such as the prevention of tuberculosis.

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[a] Ditman, loc. cit., p. 17.

[b] L. L. Seaman, "The Real Triumph of Japan," New York (Appleton), 1906, pp. 106–7.

On the question of army diet, see Blackham: British Medical Journal, 1908, August 8, p. 311.

We are laboring, in conjunction with the American Medical Association, the American Public Health Association, and with the sanitary officials of as many States as we can interest, to extend the registration area as rapidly as possible. Ohio has just adopted an excellent law, which takes effect next year. Not a single State in the South has yet succeeded in reaching a satisfactory standard—not one of them in fact has even passed an adequate law. We are depending upon the voluntary cooperation of the States. The Government has no power, it would seem, to collect the statistics or to secure the proper registration of births and deaths by its direct action. If all of the important interests involved could be awakened to the importance of this matter, if Congress would take a direct interest in the accomplishment of this work, we could secure fairly complete registration of deaths for the United States within the next ten years.[a]

CHAPTER VIII.—*Conservation through semipublic hygiene.*

SECTION 1.—*Medical research and instruction.*

By semipublic hygiene is meant hygiene through nongovernmental institutions, including institutions for medical research, the medical profession, hospitals, sanatoria, associations, schools, and factories.

Medical discoveries have usually been made in the laboratories of medical schools, universities, and research institutions. The practical value of these institutions is only beginning to be appreciated. The benefits already received from them are great, and the benefits to come will be incomparably greater. One of the earliest medical laboratories, the Pasteur Institute of Paris, has done splendid work during the past two decades in the study of harmful and beneficent bacteria. Of more recent origin are the British Sanitary Institute in London, the Rockefeller Institute for Medical Research, the Memorial Institute for Infectious Diseases at Chicago, and the Nutrition Research Laboratory in Boston, under the Carnegie Institute of Washington. The recent achievement of Dr. Simon Flexner in finding a serum for the treatment of meningitis is but one example of what well-directed research under the auspices of such institutions can accomplish. The crowning achievement of science in the present century should be, and probably will be, the discovery of practical methods of making human life healthier, longer, and happier than heretofore.

The medical schools in this country number 156. They are rapidly advancing, although the great majority are still ill equipped for providing intending practitioners with the most recent and useful knowledge. The future practice of medicine depends more on the character and aims of the medical schools of to-day than on any other factor. At the dedication of the Harvard medical buildings in 1906, President Eliot laid down as the primary duties of that school the study of the prevention of disease and the education of the public. The need of such a school especially devoted to prevention has been fully discussed by Doctor Ditman.[b] Several universities have courses, or are taking steps to give courses in the fields not only of public hygiene and preventive medicine, but also of personal hygiene and home economics.

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[a] Letter from Dr. Cressy L. Wilbur. See also Irving Fisher, "Mortality statistics of the United States census," publication of the American Economic Association, 1899; and R. Dudfield, "A critical examination of the methods of recording and publishing statistical data bearing on public health," Journal of the (Royal) Statistical Society, March, 1905.

[b] See N. E. Ditman, M. D., "Education and its economic value in the field of preventive medicine," Columbia University Press, Vol. X, supp. to No. 3, June, 1908.

One difficulty in establishing such a school is the lack of students who can afford the means or the time to attend. This was the experience of the George Washington University, in Washington, when a course of this kind was offered. For this reason it is gratifying to see that an effort is being made to throw open the research laboratory of the Public Health and Marine-Hospital Service for the use of health officers detailed from their several States and municipalities. In England the degree of D. P. H. (diploma in public health) is given those who meet the high standard set there for health officers.

During the last few years the American Medical Association has been seeking to study, classify, and improve the medical schools in the United States. A large committee, of which the writer is one member, has been appointed by the association to consider methods of securing such improvements as are deemed necessary. It includes in its scope the important but heretofore little appreciated field of medical economics.

SECTION 2.—*The medical profession.*

We come next to the part played by physicians, so far as relates to their "private practice." Their work as public health officers has already been mentioned, and does not concern us here. Their work in the home is of primary importance. It is on the physician that the average man relies for protection when he finds himself in the dread grip of disease.

Private practice comprises two main divisions, surgery and general practice. The first important application of the knowledge of germs was to surgery. Antiseptic surgery, originated by Lord Lister, has resulted in the saving of untold thousands of lives and has led in turn to aseptic surgery, which is still more effective. Not only has it reduced the previous mortality from operations, but it has vastly increased the number and kind of operations which can be performed in cases which under the old régime would necessarily have proved fatal.

Of one of the most recent advances the eminent surgeon Dr. W. J. Mayo writes:

> Second only to the germ theory has been the usefulness of the great discovery of Röntgen and the application of the X-ray to surgical diagnosis. It makes certain the diagnosis in a large number of conditions which were previously a matter of speculation, and enables remedial surgical measures at an early date, lessening mortality and morbidity.
>
> Another great surgical discovery is the suture of blood vessels evidenced by the work of Carrel. Its possibilities are astounding. The ability to transplant the kidney of one dog to another and have it continue its function, the amputation of a leg and its resuture, opens up the whole question of the transplantation of sound for diseased organs, especially organs which are double.[a]

In these and other surgical work a certain amount of vivisection is necessary. The present outcry against vivisection is an example of a defective sense of proportion. While needless cruelty should be avoided, the suffering of animals through vivisection, including all cases where the practice has been abused, is as nothing compared with the suffering of human beings which would be caused if all vivisection were abolished.

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[a] Letter from Dr. William J. Mayo.

The progress of antisepsis has so reformed midwifery that puerperal fever, a former scourge of humanity, is now extremely rare. In many cases the child, by being freed from gonorrheal contamination by the mother at birth, has been saved from blindness.[a]

The advance of surgery is shown by the following table of mortality of the wounded in the wars of the nineteenth century. Antiseptic surgery was introduced at the time of the Franco-Prussian war in 1870–1:

	Per cent.
Crimean war, English troops	15.2
French troops in Italy, 1859–60	17.4
German army, 1870–71	11.1
Spanish-American, 1898	6.6
Transvaal, 1900–1901	5.5

In general practice progress is also being made. The use of violent drugs is fast going out of fashion. The recognition of the self-limiting character of most of the acute diseases sounded the death knell of the harsh drugging of the olden time. Laboratory experimentation and careful study as to the physiologic and therapeutic effects of drugs have shown the necessity of subjecting everything material or immaterial, intended for the relief of human ailments, to the crucible of the most rigid scientific scrutiny. This sentiment has grown until in the best medical circles it is properly considered a reproach for a physician to use any preparation without an exact knowledge of its composition and a definite conception of the results expected from its administration. The number of medicines used by physicians is decreasing and will, if the predictions of experts in this field may be trusted, ultimately be reduced to a small fraction of the present pharmacopœia. Many medicines, like quinine and mercury, will of course merit a continuance of use. Syphilis, malaria, hookworm disease, and some other diseases are best combated by drugs.

Serum therapy, although in its infancy as to most diseases, has opened up a field of great promise. For example, antidiphtheretic serum, the one best understood and in most common use, has reduced the mortality in that disease from 50 or 60 to 12 or 14 per cent.[b] Not so much medicines or serums, but hygiene, will probably be the dependence of the next generation of physicians. Possibly the term "medicine" will some day be almost as inappropriate in describing the treatment toward which physicians are tending as the term "leech" now is in describing the physician. The profession has ceased to be hostile to hygienic treatment, and is slowly but surely substituting it for much of the internal treatment formerly employed. The new treatment includes the use of air, light, water, food, rest, massage, mechanical vibration, electricity, exercise, and suggestion, under the names of aerotherapy, hydrotherapy, psychotherapy, etc. These remedies have the great advantage of preventing as well as curing disease.

It only remains for all medical schools and the courses of lectures now gratuitously provided by the American Medical Association for all county medical societies to teach these things in such a thorough and practical way as will reach the whole profession and bring these benefactions to the whole people. In proportion as prevention is more important than cure, the rapid advance in the knowledge and practice of preventive medicine will be of value.

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[a] Elie Metchnikoff, "The Nature of Man," New York (Putnam), 1903, p. 210.
[b] Metchnikoff, "The Nature of Man," p. 212.

"To hygiene belongs without a doubt the place of honor in modern medicine. It is in the prevention of infectious diseases that the interest of the medical art is now mainly centered."[a] The best men are turning to these physiologic methods with enthusiasm.[b] They are learning to take into account the anxiety and other mental reactions of the patient as to what is said in his presence.[c] They are becoming more public-spirited and cooperative,[d] and alive to their responsibility to set patients a good example in living hygienic lives.[e]

The trend toward prevention is indicated in various ways—by the fact, for instance, that some physicians are now employed by families, schools, firms, associations, etc., for the purpose chiefly of preventing rather than curing disease. Women dentists graduating from the University of Michigan have made a practice of attending to children's teeth at a stated amount per month. Employers are increasingly securing the services of competent physicians to care for the health and physical welfare of their employees. This is a preventive measure, and has been found to be a "paying proposition" to the employer because of the resulting enlarged efficiency of the workers.

Their modern fight against tuberculosis has led physicians to a larger use of fresh air in their practice. At first many employed this agent merely as a "specific for tuberculosis," but its utility in all chronic ailments, such as neurasthenia, for instance, was next recognized. Latterly, fresh air has been discovered to be of use in pneumonia and other acute diseases. It is now not unusual to find physicians advising their patients, whether ill or well, to sleep out of doors. There can be no question that man was originally an outdoor animal.

The discovery of the germ origin of Asiatic cholera, tuberculosis, diphtheria, typhoid fever, bubonic plague, influenza, and other diseases, and of the part played by water, impure food, insects, rodents, and other common and almost omnipresent, but hitherto unrecognized, agencies as carriers of disease to man and animals, has awakened a world-wide interest in these subjects which, properly fostered and directed, opens up ever extending possibilities to the humanitarian, the economist, the statesman, and, still more, to the people at large.

The consequence must be a great revolution in medicine in the immediate future. The practice of medicine is destined to become a much more powerful agent than ever before in the suppression and prevention of disease. This result will be reached when the change now going on permeates the rank and file of the profession. It would be a pity if, through undue conservatism of some of its members, the profession should lose some of its prestige hard won during the last generation. Already the ever-present quack is pressing into the inviting field. As the public demands "drugless treatment" and many physicians fail to see and meet that demand so far as it is rational, the quacks see their opportunity. As a consequence, there is fast developing a species of quack that not only does not use "patent medicines," but condemns their use by regular physicians. Men of this type base their appeals on "naturopathy," become "food experts," prescribe fasting, or two meals a day or five meals a day, give lessons in "deep breathing," conduct outdoor sanatoria, and employ light and air baths, dry cupping, mechanical vibration, intestinal lavage, water cures, electricity, osteopathic manipulations, "divine healing," etc. All these methods have value under certain conditions; the only objection is that when applied by the uneducated they are utilized to poor advantage. The fault lies not in the therapeutic means but in those who use them. Physicians sometimes confuse the two, and make the mistake of opposing the means and user alike. They reject good means of cure because employed by "irregulars."

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[a] Metchnikoff, "The New Hygiene," Chicago (Keener), 1906, pp. 12-13.

[b] See G. Stanley Hall, "Adolescence," New York (Appleton), 1905, vol. 1, p. 235.

[c] See A. T. Schofield, "Power of Mind," London (Churchill), 1902, 2d ed., p. 277.

[d] See Osler, "Maryland Medical Journal," October, 1905, p. 420.

[e] See Professor Osler's address to St. Mary's Hospital, London, 1907.

The result is that the patient sometimes finds the best means of recuperation in the hands not of medical men, but of uneducated "physical trainers." The public will go and should go to those who will render the most effective help. In order that the medical profession may suppress quackery the way must be not to oppose the use of beneficial therapeutic agents in incompetent hands, but to get their use into competent hands by adopting them themselves. There is a quackery that is villainous and injurious. This should be suppressed. But there is another quackery which is well intentioned and which, in spite of ignorance, manages to do some good. The good in it should be appropriated by the profession. By always promptly absorbing the best the profession will be in a position to cast out the worst in "irregular" systems of therapeutics. It may then recover the ground which it has too often lost. There was no reason why it should have lost hundreds of thousands of patients to "Christian Science," except that these patients were for the most part benefited, and greatly benefited, by Christian Science after having received no benefit, and often injury, from the profession. "Easily physicians, without knowing it, can produce sickness by pessimistic prophecies, by anxious looks or words. Thus are diseases suggested (unconsciously) by the physician."[a] Had the profession made use of mental therapeutics not only could they have saved themselves the enmity of these hundreds of thousands, but they could have nipped in the bud the crude metaphysics which teaches the nonexistence of disease and death and the uselessness of any therapeutic agent except those employed by the promulgator. The example of so-called "Christian Science" is only one of several protests, more or less misguided, against the present practice of medicine.

Had all or most members of the profession conceded long ago the harmfulness of many, if not most, violent drugs it might have forestalled the present antidrug movement among the laity. The misguided antivaccination movement is simply the carrying to extremes of the antidrug movement.

The Greeks were probably the most hygienic people that ever lived and they knew nothing of modern scientific medicine, not even of the circulation of the blood. This shows that man's primitive knowledge or instincts may be sufficient to enable him to keep and develop health.

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[a] Schofield, loc. cit., pp. 215-216.

The old code of medical ethics, though well-intentioned, was so inelastic and was so susceptible of misconstruction as often to block the way to progress. The magnitude and far-reaching effects of this evil were long ago recognized by leading minds in the profession, and after years of agitation such a revision was unanimously agreed upon in 1903 as makes the modern principles of medical ethics purely advisory and far more liberal than formerly. All restrictions as to consultations were removed, medical societies were thrown open to reputable physicians of every school of practice requiring scientific training, and agencies put in operation for such organization and cooperation and to encourage such liberty of individual opinion as is demanded by the spirit of the age. Under the most active efforts of the medical schools, societies, and journals it will doubtless require years of time for this liberal spirit to reach all members of the profession to the extent which is so desirable. But when this is done and when the public can be made to understand that it has been done the prejudice which has hampered the profession's usefulness, which has made it so difficult to secure and enforce health and medical legislation necessary for the protection of the highest interests of the people and which has so fostered and given opportunity for quackery, will gradually become ancient history.

A frequent lay comment on some members of the medical profession is that to be true teachers of health they must practice what they preach. A physician can not succeed in controlling drug habits or alcoholism if he has these habits himself. He can not fight "patent medicines" if he uses them himself.[a] He can not effectively fight the social evil if he himself practices abortion. The standards of the profession are high. It is the individual who is at fault. A clergyman who preaches purity from the pulpit while living a double life is disgraced. In the same way, now that physicians are assuming the function of giving instruction in orthobiosis and hygiene, they are being called to account for their own daily lives. Self-interest and altruism alike will lead to needed corrections. The physician in these days of preventive medicine should keep himself well. The challenge "Physician heal thyself" is being followed by the challenge "Keep thyself well." Example more than precept is a principle to be applied here as elsewhere. He can not induce his patients to diet or take exercise if he himself is addicted to the fleshpots and the easy chair. Many a physician to-day loses patients because he and his family are on the sick list, or because as a man he practices habits which as a physician he does not approve.

The physicians in this country now number about 130,000. Their calling is in some respects the noblest in the world to-day. During the present generation the profession has begun to be appreciated for its great services to public and private health and for its self-sacrifice, which is unequaled in any other profession except the ministry. It has now before it an opportunity such as never before existed. Those of us who believe in its mission look forward to incalculable blessings to suffering humanity from greater knowledge better applied.

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[a] See A. Jacobi, Journal American Medical Association, September 29, 1906, p. 978.

SECTION 3.—*Institutional hygiene.*

The large cities have established special contagious hospitals, where prompt isolation of infectious cases may be enforced. The decrease of tuberculosis may be traced largely to hospital isolation.[a] Leprosy was the first disease to be quarantined[b] and its virtual disappearance in civilized countries has been due, at least in the opinion of many authorities, to the strict isolation methods universally adopted.

Of a different kind is the segregation of defective classes of the community. This has led to considerable conservation of their powers and abilities. Institutions for the deaf and blind in the United States contained 14,700 inmates in 1904, and spent for purposes of maintenance over $3,500,000.[c] In these schools the deaf and dumb and the blind are taught trades and professions, their usefulness being thus much enlarged.

The New York state commission on the blind recommended in 1907 a state board for the blind to conduct an employment bureau for the blind of that State, to establish schools, and to put into operation measures for the prevention of blindness. It is pointed out that of the 100,000 cases of blindness in the United States a great percentage is traceable to disease and accident of a preventable character. The commission estimates that of 1,000 cases in New York, 450 were possibly avoidable and 325 (or one-third) certainly so.

For the checking of insanity the crying need is a study of the causes of the malady with a view to its prevention. For, as Doctor Ditman remarks, nine-tenths of the inmates of our insane asylums are incurable, according to our present knowledge. He adds: "What an argument for the prevention of the disease!"[d] Much may be expected from the Phipps fund, for the study of insanity, recently established at Johns Hopkins University.

In the first place, our medical students should receive constant clinical instruction in mental diseases, particularly in their incipient stages. Almost equally important are popular lectures on the preventable and other causes of insanity given under the auspices of medical schools or local boards of health. Such lectures have been given in New York and Boston, and, judging by the attendance, must prove a valuable agency in diffusing a correct knowledge of the cause and development of mental disease. In this education of the laity popular treatises on mental hygiene would prove most helpful. Such a book as Doctor Clouston's "Hygiene of Mind" could, with advantage, be placed in the hands of every young person, and might even be adopted as a text-book in high schools. Certainly the physiology of mind is as deserving of popular consideration as that of digestion, respiration, and the circulation.

By a clearer insight into the beginnings of mental disease, gained through the popular lecture and a nontechnical literature, society will become so far enlightened that intelligent personal prophylaxis may be anticipated.[a] A knowledge of danger is the surest means of guarding against it. "The most obvious line of attack must be in the direction of the four great etiological factors of insanity, heredity, alcohol, syphilis, and environment. Abstractly considered these four causes are preventable or removable."[b]

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[a] See Newsholme, "Phthisic death rate," Journal of Hygiene, July, 1906.

[b] See J. M. Eager, M. D., "The early history of quarantine," Yellow Fever Institute Bulletin No. 12, pp. 4–5.

[c] Census report on "Benevolent institutions," 1904.

[d] Ditman, loc. cit., p. 46.

As an intermediate step between home and hospital, the sanatorium offers both cure and prevention. Many tuberculosis sanatoria will take patients only in the incipient and early stages of the disease. Sanatoria are used by many as places of recuperation. The tired business man and the nervous housewife find at the sanatorium the quiet they need, and a week or two of rest enables them to escape threatened serious ills.

Many public institutions, in response to popular demand, are today installing methods and equipment that are essentially preventive. More than one department store in the large cities filters its air in order that patrons and clerks shall not feel oppressed by vitiation of the atmosphere. An indirect result is the prevention of tubercular and other diseases. A leading hotel in Philadelphia has pitched tents on its roof, where a large colony of well people—not sick—sleep out of doors, and the same hotel utilizes its roof in winter for a skating rink. Mothers' clubs are an increasing factor in the spread of a knowledge of hygiene. Recently a case came to light of a new member of a mothers' club who was feeding her 5-months-old baby on sausage, tea cake, etc., and giving it drugs when she wanted to go out. She was greatly surprised when informed of the wrong she was doing.

Growing interest in the science of home economics, already referred to, is an indication of our increasing realization of the importance of healthful homes in the community. While the number of schools and colleges which offer courses in higher domestic science, and in what might be called "true home economics," is growing, they are nevertheless still comparatively few. More teachers should be equipped with scientific knowledge regarding modern sanitation in order that they may give practical courses in grammar and high schools, and higher instruction should include the topics of hygiene and sanitation. Home making may be studied in many details, such as the construction of healthful houses, the purification of food and water supplies, and the cleansing of cities, whereby the enlistment of both boys and girls in all lines of home and municipal hygiene can be secured.

The churches are now joining in the health movement. The lead has been taken by the Rev. Elwood Worcester and Rev. Samuel McComb at the Emanuel Church in Boston. Trained physicians are employed for diagnosis and for general advice, but great emphasis is laid on the power of suggestion and of Christian self-control over bodily ills. The object is to get both patient and physician to stop "thinking sick and talking sick," as Doctor Goler has put it.

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[a] A book which brings the subject home with unusual force to the ordinary reader is an autobiographical sketch by a recovered patient, "A Mind that Found Itself," by Clifford W. Beers, New York (Longmans, Green), 1908.

[b] Charles P. Bancroft, M. D., "Hopeful and discouraging aspects of the psychiatric outlook," address at meeting of American Medico-Psychological Association, Cincinnati, 1908.

SECTION 4.—*School hygiene.*

In every progressive country to-day the hygiene of school life is coming to be regarded of paramount importance. At the International Congress on School Hygiene, in London, August 5–10, 1907,[a] there were in attendance at least 500 delegates, representing the governments of the world and societies devoted to the advancement of human welfare, and in addition there were 1,500 individuals interested in the improvement of the health of school children and all that this implies. The fact was brought out at the congress that European countries, notably Switzerland, Germany, France, England, and Scotland, are doing more than the United States in the medical inspection of schools and that they are seemingly making plans for the improvement in every direction of the hygienic conditions of school life.[b] Even in Italy the leading statesmen are apparently convinced that the matter of chief importance at the present moment in their educational work is to place it, from start to finish, upon a hygienic basis.[c]

It is the unanimous opinion of all students of the matter that the neglect of the hygiene of school life in the larger sense is, first of all, more or less disastrous to a considerable proportion of the pupils.[d] With us, as well as in most European countries, children are compelled by the state to attend school for a number of years. Many of them suffer constantly from defective vision, hearing, and respiration, from nervous overstrain, and from other ailments which are greatly aggravated by the confinement and stress of school life.[e] Pupils are always exposed to infectious diseases. It is no unusual thing in our country to see a contagious disease sweep through a whole school so rapidly that the local board of health can hear of it and order the school closed only after the harm has been done.

Great as is the injury done by the spread of infectious diseases to children thus massed together in schools, the injury resulting from imperfect seating, lighting, ventilation, and sanitation of school buildings is still more serious. In every part of our country, as well as in the progressive countries of Europe, those familiar with the situation are appealing most urgently for improvement in the physicial basis of education. This is not the place to recite the disabilities which are said by men competent to speak on the subject to result from keeping children for at least eight years in confinement and at hard mental labor under conditions that waste their vitality and develop bodily defects and habits prejudicial to health. The list of such disabilities is a long and impressive one.[a] Unfortunately, we do not, as a people, sufficiently appreciate that the character of social life with us is changing rapidly, and that consequently our children are particularly susceptible to certain diseases and defects; to wit, those arising from the adoption of an indoor life of comparative muscular inactivity, with greatly increased demands made upon particular organs, such as the eyes and the brain.

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[a] The proceedings of the congress contain papers by distinguished physicians and educators upon every phase of the hygiene of school life. Existing evils are pointed out and remedies suggested. Summaries of the papers may be found in the Nineteenth Century, September, 1907, pp. 388–394.

[b] In addition to papers presented at the International Congress on School Hygiene, see the following: A series of articles in the School Review (University of Chicago) for 1907, by Prof. Hermann Schwartz, entitled "The study of experimental pedagogy in Germany." Many articles in the magazine Zeitschrift fur Schulgesundheitspflege show the great interest in Germany in school hygiene. Professor Binét, of Paris, has established a laboratory for the study of childhood in relation to educational work, and he will give particular attention to problems concerning physical defects and mental and moral shortcomings. For other such institutions see The Psychological Bulletin, Vol. VI, March 15, 1909, pp. 84–103.

[c] See, for example, Professor Garlanda's "Il Terzia Italia," in which he shows the only way in which Italy can regain her old-time vigor and efficiency.

[d] See M. V. O'Shea: "Dynamic Factors in Education" New York (Macmillan), 1906, Part II, where the whole subject is discussed.

[e] See Oppenheim: "The development of the child," Chap. V. Also Tyler: "Growth and education;" Burbank: "The training of the human plant;" Burk: "From fundamental to accessory," etc.; Pedagogical Seminary, Vol. VI, Kræplin: "A measure of mental capacity," Popular Science Monthly, vol. 49.

Doctor Cronin, of New York, maintains that in a school population of 650,000, 30 per cent of the children were from one to two years behind their proper class. Ninety-five per cent of these backward children were so principally because of defects of eye, ear, nose, or throat, which could easily be detected and remedied through effective medical inspection. Experiments at home and abroad have proven beyond any doubt that the majority of children of this sort, when given proper medical treatment, improve markedly in intellect and general conduct. The State attempts to educate these children, but its effects are to a large extent wasted. Doctor Osler calculated that in the special city to which reference has been made there was, on account of a lack of medical supervision of educational work, a yearly financial loss of $1,666,666; and of course the loss which came from moral deviation due to defective physical functioning was of far greater importance. Doctor Osler said recently, in effect, that he considered it of greater importance to the nation that the question of sound teeth be intelligently considered than that the consumption of alcohol be restricted, important as the latter problem is. In similar vein, Doctor Newton reports a case of an old, unhygienic school building in a small town being fitted up with a ventilating system, with the result that the cost of the improvement was saved in a short time in salaries that otherwise would have been paid to extra teachers for taking the place of those made sick by the foul air in the building.

We now know the major effects at least on intellect and temperament of sense defects, adenoids, decaying teeth, and minor physical deformities; and we also know how such deviation from normality can be readily and inexpensively detected and remedied,[b] but there are whole States where no advantage whatsoever is taken of this knowledge, and in practically every State in the country there are communities in which absolutely no attention is paid to any of these matters. The people go on in traditional ways, trusting to luck and disregarding the changes taking place in society.

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[a] See Shaw: "School hygiene;" Keating: "Mother and child;" Ballantyne, in the Lancet, Vol. 2, 1890; Bancroft: "Physical Education Review," Vol. VII; Rowe, "The lighting of schoolrooms;" Burrage and Bailey: "The Sanitation and decoration of school buildings." The Magazine of School Hygiene, published under the direction of the School Hygiene Association, contains in each issue articles showing the evils resulting from unhygienic conditions in the schools.

[b] See, for example, two books by Doctor Warner, of London: "The Study of Children" and "The Nervous System of the Child." The city of Chicago maintains a department for the study of backward and defective children in the public schools.

The health of our school children, then, should be conserved by a system of competent medical inspection[a] which should secure the correction of defects of eyes, ears, teeth, as well as defects due to infection or malnutrition. In Europe—

> all the investigations disclosed an astonishing amount of ill health among school children; and though the variations from the normal were found to differ in degree, they were on every hand alike in kind. In nearly every instance they were more pronounced in girls than in boys, and were often most manifest in scholars of the better social classes. Thus there were discovered the following percentages of morbidity among school boys: In Great Britain, 20; in Denmark, 29; in Germany, 30; in Copenhagen, 31; and in Sweden, 37. The percentages noted among the girls were: In Great Britain, 16; in Copenhagen, 39; in Denmark, 41; in Lausanne, 43; in Germany, 50; and in Stockholm, 62—an average morbidity for boys of 29 and for girls of 42 per cent.[b]

Similar results have been reached in certain cities of the United States. A "committee on the physical welfare of school children" in New York City examined New York school children and found that[c]—

66 per cent needed medical or surgical attention or better nourishment.

40 per cent needed dental care.[d]

38 per cent had enlarged glands of the neck.

31 per cent had defective vision.

18 per cent had enlarged tonsils.

10 per cent had postnasal growths.

6 per cent were undernourished.

Dr. Walter Cornell has been making an extensive study of eye strain among school children. These were his findings:[e]

> The relationship of poor vision to scholarship was studied in 219 children. As will be noticed, the difference in marks between those with normal and those with bad vision is greatest in arithmetic and spelling, which studies require more extensive use of the blackboard.
>
> *Scholarship percentages obtained.*
>
> | Children with— | Arithmetic. | Geography. | Spelling. | Average. |
> |---|---|---|---|---|
> | Normal vision | 79 | 69 | 76 | 75– |
> | Fair vision | 70 | 71 | 77 | 73+ |
> | Bad vision | 66 | 70 | 71 | 69 |
>
> In New York City 29.5 per cent of 79,069 children examined suffered from defective vision. In London 26 per cent of 20,000 children examined by eight

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[a] See Gulick and Ayres. "Medical Inspection of Schools," Russell Sage Foundation Publication, New York, 1908; see also "The Psychological Clinic," especially Vol. ii, No. 8.

[b] G. Woodruff Johnson, M. D., "Effects of school life on children's health," North American Review, vol. 182, p. 831.

[c] Ditman, loc. cit., p. 41.

[d] This seems a low estimate in spite of the fact that it does not include all cases of decayed teeth, but only those that have been neglected. See Dr. William R. Woodbury, "The People's Disease: How to Prevent it," Boston Medical and Surgical Journal, March 26, 1908.

[e] "Backward Children in the Public Schools," Philadelphia (Davis), 1908, p. 7.

opthalmologists had defective vision, and of this number 12.5 per cent suffered from vision of one-half or less. The author examined personally 1,156 children and found 34 per cent with defective vision, and of this number 6 per cent with vision one-half or less. A small proportion of this number only is fitted with glasses. The rest suffer from real eye strain. The fault of this deplorable condition is divided among physicians, school-teachers, and parents. Ignorance of the existing facts, indifference, and poverty are the real factors to be dealt with.

Eye strain is the chief source of the functional diseases of our citizens. It begins in early childhood and continues until senility is complete. It is bound to occur in every individual some time in his life, to a greater or less degree. It is almost the sole cause of headache, migraine, sick headache, the most frequent and habitually morbidizing of human diseases. It is the frequent cause of gastric and digestional diseases and of nervous and mental diseases. With ocular function it conditions the origin of spinal curvature, either directly or indirectly, through the pathogenic writing posture. Lateral spinal curvature, the effect of visual function, becomes a new secondary source of multifarious morbidities, such as neurasthenia, pelvic diseases, hysteria, etc. It has been demonstrated that 27 per cent of European school children have lateral spinal curvature at the age of 14, and I have proved that at least 70 per cent of our own 16 to 18 year old young men of the educated classes have this disease. Surprise at the fact will soon become horror at the national and social tragedy which these true figures indicate.[a]

Investigations in other cities and States[b] have shown similar results, in view of which it is a conservative statement to say that from one-half to two-thirds of our school children need medical treatment of some sort.

At least one year in each division of schooling, elementary, secondary, and collegiate, is lost to the majority of students because of unnecessary sickness or dullness caused by improper living.[c]

That physical defects are responsible for much of the backwardness of children, and for a large share of truancy and incorrigibility, is the opinion of many educators.[d] In order to correct physical abnormalities and thereby to hasten mental and moral progress in school life, a number of cities have instituted medical inspection of schools.

So far as inquiry has been able to discover, there were in the month of June, 1908, 70 cities in the United States, outside of Massachusetts, having some form of medical inspection of schools. In the State of Massachusetts 32 cities and 321 towns had systems more or less complete. It is at present impossible to compute, or even to closely conjecture, how many children these systems reach at the present time. It is entirely certain that they do not reach all of the children in the schools of those cities and towns where systems of medical inspection are actually or nominally in operation.[e]

New York City employs 150 physicians, who visit each public school once a day, shortly after 9 o'clock, to examine those children set aside by the teacher as requiring attention. Chicago employs nearly 100 physicians to visit her public schools. In Chicago during the ten months of the school year ended June 26, 1908, the medical inspectors of schools examined 406,919 pupils.[a]

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[a] Letter from Dr. George M. Gould, who perhaps more than any other American has emphasized the evils of eye strain.

[b] See an article by Prof. M. V. O'Shea in the World's Work, Vol. V, in which the results of extensive investigations were given. See also Dr. W. B. Drummond: "An introduction to child study," Chs. IX and X, "Report of Conference of State Sanitary Officers of New York," Buffalo, October, 1907, and various Baltimore and New York City school reports.

[c] Letter from Mrs. Ellen H. Richards.

[d] See O'Shea: "When character is formed," Popular Science Monthly, Vol. LI; Rowe: "Physical nature of the child," Chs. 9, 10, 13, 14; Scott: "Sacrifice of the eyes of school children," Popular Science Monthly, October, 1907; Gould: "The cause, nature, and consequences of eye strain," Popular Science Monthly, December, 1905; Travis: "The Young Malefactor, a Study in Youthful Degeneracy;" Swift: "Mind in the making," Chs. IV and V; Tanner: "The child," Ch. III; Kirkpatrick: "Fundamentals of child study," Ch. XVII.

[e] Letter from Dr. Luther H. Gulick.

And one health officer, Doctor Chapin, of Providence, has even established a special fresh-air school for children who suffer from certain forms of tuberculosis or who come from tuberculous families. He says concerning it:

> Our fresh-air school has only been running since last January (1908), and, of course, we have no very definite results. All of the children without exception improved in health, and gained in strength, and also showed good mental progress. The cost of the school per capita is only about 50 per cent more than in the ordinary schools, and we believe that the expense is fully justified. If we had a large enough school, so that it could be graded, the cost of education would, owing to saving in fuel, probably be less than in an ordinary school.

Several States are making progress in these directions.

> Connecticut, Massachusetts, and Vermont have passed laws making examination of eyes, ears, and method of breathing of the public scholars compulsory, while New York, Illinois, and some other States of the Middle West depend upon the voluntary cooperation of the teachers in making this examination. It would seem, however, that whether it remains voluntary or becomes compulsory, its success will be greatly enhanced if women who are conducting teachers' institutions in the department of education devote a half hour or an hour to the exposition of the necessity of such an examination and also in explaining the method in detail and the method of tabulating the results, so that the teachers may be familiar with the tests, etc., when they have to make them. With the great power lodged in the department of education in this State, it would seem justifiable to make this compulsory.[b]

We in this country should profit by the experience of older countries in respect to school hygiene. Switzerland has led the nations in its concern for the physical welfare of its children. A number of other European countries are beginning to imitate Switzerland in attaching supreme importance to health and hygiene in educational work. There is now before the English Parliament a bill the purpose of which is to establish a national system of medical inspection of schools, and it seems probable that this measure will be enacted into law.

It is generally recognized by physicians and educators to-day that many children in the schools are being seriously injured through nervous overstrain.[c] Throughout the world there is a developing conviction that one of the most important duties of society is to determine how education may be carried on without depriving children of their health. It is probable that we are not requiring too much work of our pupils, but they are not accomplishing their tasks economically in respect to the expenditure of nervous energy. Some experiments made at home and abroad seem to indicate that children could accomplish as much intellectually, with far less dissipation of nervous energy, if they were in the schoolroom about one-half the time which they now spend there. German educators and physicians are convinced that a fundamental reform in this respect is needed. In fact, among school children we are learning the same lesson as among factory employees, viz, that high pressure and long hours are not economy but waste of time.

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[a] A. L. Craig, "Report of the standing committee on contagious, infectious, and hereditary diseases," Associated Fraternities of America, August 1, 1908.

[b] Twenty-eighth Annual Report State Board of Health of New York, 1908.

[c] See Dr. Adolph Meyer, "What do Histories of Cases of Insanity Teach Us Concerning Preventive Mental Hygiene during the Years of School Life?" The Physchologic Clinic, June 15, 1908.

In American cities one of the greatest needs to-day, in order to conserve the vitality of children, is the establishment of playgrounds easily accessible to all the children of any community. We are told that the physical and the mental are inseparably joined together, and if the one is defective the other will suffer through sympathy. Now it appears to be impossible to develop the child physically in any way so effectively as through active play. Formal gymnastics can accomplish relatively little. The child must have some end to attain that arouses its enthusiasm, and that demands agility and strength and endurance; then its whole bodily mechanism will work together in harmony to achieve this end. And this is what a physical training seeks to accomplish—to make the body a fit instrument for the mind. Let the child have some place where it may not only play games freely without fear of the police but where it may run and jump and climb and swing and work in sand and throw stones and wrestle, and it will not fail to make the most out of the body nature has given it as a housing for a sound and efficient mind.

Even if playgrounds were of no value in social development, they would still be of inestimable service in keeping children out of crime and lessening expense for police, courts, reformatories, hospitals, and prisons—a point which was strongly emphasized in the report of 1897 of the committee on small parks in New York. If a boy's energies are not used up in wholesome activity they will surely find expression in illegitimate conduct. The boy will prey upon the institutions which prevent him from living a natural life. "The greatest enemy to the police is the boy," said a high Philadelphia official recently. Go to the storekeeper, to the shopkeeper, to the housekeeper, and you will hear the same story. The boys steal, break windows, insult, afflict, upset one thing and another, and would do almost anything they hear or see in order to satisfy that burning instinct for play. "These beginnings of vice and crime were the only outlets they have had for the powers with which nature has endowed them. These practices were their only or chief amusement, and thus happiness to them became synonymous with vice and fiendish delight in evil doing."[a]

But in studying the life on the playgrounds the same official sees that they lay the foundations for—

> strong, manly, bright, and happy lives, rescued from the evil habits and tendencies that produce misery and wretchedness. * * * Through their play in this manner the young are taught how to live together, how to respect each other's rights, how to be kind, gentle, pure, in language as well as in conduct. The boy's mouth is not defiled by tobacco, liquor, or profane language. The disrespectful and vulgar treatment which young boys and girls inflict upon each other in the street is done away with. The playground influences are brought into the home, where the younger brothers and sisters treat each other much differently from the way they do now; or, to put it the other way, the influences of the home, the school, and of the church are thus extended outside over the whole life of the child.[a]

To playgrounds may be joined school gardens, which Superintendent Maxwell in New York has shown would not be expensive, or open-air gymnasia, or any other equipment that will give children the opportunity to develop physically.

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[a] Secretary of Philadelphia Culture Extension League.

Physical education is a part of the training in many public schools and in a still greater number of private schools, but there is room for improvement. After pointing out, in a recent article on physical deterioration, that Germany, France, and Austria have improved their physical development by compulsory physical training in all civil and military educational institutions, the Rev. Percy Stickney Grant advocates the instalment in the United States of:

> 1. An effective system of physical education as a recognized part of all public-school systems. By "effective" I mean one that does for a boy, as far as his physique is susceptible, what army setting-up exercises do for a recruit.
> 2. Athletic exercises in schools, using gymnasia, baths, etc.
> 3. Open-air exercises and sports under efficient supervision.
> 4. Summer camps free of cost, and compulsory attendance for boys of school age.[a]

The study of hygiene and physiology has been part of the public school curriculum for some time, but has been regarded by physiologists as a somewhat partisan and unscientific treatment of the physiological effects of alcohol and tobacco. It should be recognized, however, that it has had a salutary effect and has given school children a better idea of what alcohol means than the most of them had before.[b] Local topics of sanitation may well be taken up, as in New Haven last year when the interest of all the city school children was enlisted in behalf of a "clean city." Doctor Stiles, of the Public Health and Marine-Hospital Service, has proposed an annual "health week" in the public schools, and this proposal has found favor in several States. In Georgia Chancellor Barrow has proposed an annual "health day" in the public schools of that State, which would be devoted to lectures on sanitation, on the dangers to be expected from unscreened windows, and on the character of the hook-worm disease, with suggestions as to its elimination.

> At present the schools look to parents to instruct their children in the supposedly simple matters of regulating eating and drinking, exercise, habits of work, and sexual habits, while the parents vaguely hope (if they think about such matters) to be relieved of these embarrassing duties through the schools. The truth is that neither parents nor schools are to-day able to give this much-needed sort of education. The remedy must be provided by the schools, which in their eagerness to impart conventionalized facts are now quite blind to some of the most pressing needs of their pupils. Through the schools and universities (or other appropriate organizations) the parents of the future must be educated both as to the facts and the moral aspects of bodily hygiene. And it seems not unreasonable to hope that some of the lessons now learned only by bitter experience, after much that is best in life has been sacrificed to ignorance and uncurbed impulse, will be assimilated sufficiently early in life to mitigate materially the lot of a not inconsiderable part of mankind. I beleve the lengthening of the span of human life to be among the attainable results of such teaching. Is it not likely that as men grow wiser an increasing number will deliberately strive so as to regulate their lives as to improve the expectation of crowning well-spent days with the peculiarly fine satisfaction of old age?[c]

If the school building were a model of ventilation, lighting, and sanitation, it would not only conserve the health of the school children, but also serve as an object lesson for hygienic instruction. In the same way cooking and domestic science classes could be made to serve the double purpose of providing a hygienic noon meal and training the school children, especially the older girls, in the principles and practice of this vitally important subject. Our schools are suffering from the conventional idea that education comes from books. Education is preparation for life, and should make use of every efficient method and element, manual training, athletics, observational nature study, laboratory experiments, and object lessons of all sorts, as well as book instruction.

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[a] Rev. P. S. Grant, North American Review, February 1, 1907.

[b] See Dr. Helen Putnam, "Studies of the Present Teaching of Hygiene, Through Domestic Science and through Nature Study," American Academy Medicine (Easton, Pa.), 1905.

[c] C. A. Herter, M. D., "The Common Bacterial Infections of the Digestive Tract," New York (Macmillan), 1907, p. 351.

SECTION 5.—*Voluntary and business organizations.*

A host of distinctly voluntary associations are working for the improvement of hygienic conditions. Among them may be mentioned the National Association for the Study and Prevention of Tuberculosis, the Society for Sanitary and Moral Prophylaxis, the Chicago Society of Social Hygiene, the Connecticut Society of Mental Hygiene, the national and state child labor committees, the Congress on School Hygiene, the Children's Aid societies, the Sunshine societies, the American Playground Association, the Visiting Nurses' Association, the Red Cross Society, the American Association for Labor Legislation, the numerous temperance organizations, university settlements, institutional churches, Young Men's Christian Association and kindred associations, the American Physical Education Society, the Boston Health Education League, and the American Health League established by the Committee of One Hundred on National Health.

That various large bodies of men are waking to the importance of health study is shown by the appointment, at the last annual meeting of the Associated Fraternities of America, of a committee on infectious, contagious, and hereditary diseases, with Doctor Craig, of Chicago, as chairman. Labor unions may well follow this example and provide for the education of their members in the subject of hygiene. This could be effectively combined with their endeavors to shorten the hours of labor. Especially unhygienic is the arrangement by which a man has no interest in his work beyond that represented by his pay envelope. This fact has been recognized by some farsighted employers of labor, with the result that they now employ social secretaries or "welfare workers" to look after the general well-being of employees. A social secretary watches over the health, comfort, and happiness of the force during working hours, establishes lunch rooms, rest rooms, mutual aid associations, thrift funds, and penny provident banks. Employers, as a rule, become eager for practical suggestions and expert advice on the well-being of their employees as soon as the matter is called to their attention. Doctor Favill, president of the Chicago Tuberculosis Institute, after speaking before the Commercial Club, was urged by 15 or 20 of the large employers present to undertake investigation of their establishments and to make recommendations.

Dr. Hubert Higgins describes an interesting experiment carried out in a mill near Paris, where there were employed 44 men and 75 women and children. A medical officer was employed to supervise the sanitary appliances and regulations and to give careful instruction and explanations. He held practical instruction classes with the mothers, lecturing on diet and cooking, cleanliness, the way to take body temperatures, and how to look at the children's throats.

> This experiment was entirely successful, though the doctor lived in Paris. There was not a single death in three years. There were one or two cases of scarlet fever and diphtheria, that were promptly and effectively isolated. This experiment was not philanthropic, but financial, the employer realizing that he had better value in work from healthy hands.[a]

A few factories now use or permit the use of a reader to read to their employees, where the manual nature of their work is such as not to be hindered by listening to a story. Others use a piano and have their employees march in and out to music. The curious physiological relations between rhythm and work are now being observed by physiologists. Laboratory tests with ergometers seem to show that more work can be done under the stimulus of rhythm. Soldiers and sailors have for ages made use of music and rhythm, and it would not be beyond the range of possibility if the factory system should in some cases find more use for it than at present.[b]

Unconsciously, business corporations have also made changes which tend to improve the sanitary conditions under which their employees work. In a large telephone exchange in Chicago the perfect working of the apparatus was much hampered by dust, so that insulation was seriously affected. To obviate this condition an expensive system was put into operation, by which the air was washed and pumped into the rooms under ideal conditions. What the company aimed at was the perfect health of its apparatus, but it gained in addition a decided improvement in the health of its employees.[c]

Another similar organization, the New England Telephone and Telegraph Company, at Cambridge, Mass., ventilated its offices during the winter of 1907–8 with unusual care, with the result that the number of days of work lost by its 60 female employees was cut in half.

The need of industrial efficiency is driving business men to demand temperance or even total abstinance among their employees. This is one of the most powerful motives to-day working against the abuse of alcohol. In the South employers and the public see that negroes who drink are inefficient and dangerous. Railway officers and the traveling public realize that public safety requires sober locomotive engineers and firemen. Even drinking among sailors is being discountenanced. Doctor Grenfell, the missionary among the Labrador fishermen, says: "Why don't I want to see liquor used at sea? Because when I go down for a watch below, I want to feel that the man at the wheel sees only one light when there is only one light to see."

Among semipublic institutions with power to exercise prodigious influence in improving the public health are the life insurance companies. Just as fire insurance companies make efforts to decrease the risk of fire, so life insurance companies might well join in public health movements to effect a reduction in the human death rate.

While the financial motive is sordid, it should be utilized because of its tremendous power. The insurance companies to-day represent an invested capital of over $3,000,000,000. An actuary recently remarked to me, in connection with this subject, that they could without feeling it contribute great sums annually to the preservation of public health. When insurance companies were established, the old dictum that human vitality followed a fixed law served probably to exclude the idea of preventing death claims rather than paying for them. Now that we are learning the preventability of disease, the time must come when insurance companies will take an active part in the fight. Even a single company would probably make a good investment if it sought to educate its own "risks." But a far more effective method would be a combination of all companies to improve public health through the enactment of public legislation—by Congress, state legislatures, municipal governments, and in numberless other ways.[a]

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[a] Hubert Higgins, "Humaniculture," New York (Stokes), 1906, pp. 209-211.

[b] See Karl Bücher, "Arbeit and Rythmus," Leipzig, 1902.

[c] See Outlook, May 26, 1906.

Among some official agencies meant to promote the social welfare are two recent commissions appointed by the President—the Homes Commission, of 1907, appointed for the purpose of studying the housing conditions in the District of Columbia, and the Commission on Country Life, appointed to study the daily life of the farmer. Farm sanitation will be especially considered.

Finally, there is a public yet voluntary agent in the progress of hygiene that must not be overlooked, namely, the modern periodical. Not only do the daily papers devote much attention to questions of health and hygienic reform, but the popular magazines have taken up the fight against disease, and are educating the popular mind, more surely than is realized, concerning the natural and normal way of life. It is necessary to add, however, that these same periodicals often nullify the benefits derivable from their reading matter by printing the most harmful of patent medicine, quack, drug, and alcoholic advertisements. Public odium should attach to newspapers and magazines that advertise hurtful nostrums. It is impossible to estimate the harm wrought to the public health each year through such advertising.[b]

The daily papers are especially culpable in this regard, but weeklies and monthlies are not wholly clear of the taint. When a newspaper's advertising space is once bought by quacks or nostrum sellers, its news columns become closed at once to matter considered objectionable by such advertisers. Frequently news items reflecting directly or indirectly on quackery are suppressed. Notable examples of publications that have taken strong ground against such advertising are Collier's Weekly, The Outlook, The Ladies' Home Journal, and a few—a very few—daily papers.

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[a] Since the above was written the Committee of One Hundred on National Health has urged this matter before the Association of Life Insurance Presidents, which body has appointed a committee to draw up plans. Also the Metropolitan Life Insurance Company has organized a bureau of cooperation and information to aid in distributing information to policy holders of the "industrial" class.

[b] For further discussion of this topic see a pamphlet by Samuel H. Adams on "The Great American Fraud," reprinted by the American Medical Association from a series originally appearing in Collier's Weekly, and "A Century's Criminal Alliance between Quacks and Some Newspapers," by Champe S. Andrews, Publications of the Committee of One Hundred, 1907.

CHAPTER IX.—*Conservation through personal hygiene.*

SECTION 1.—*Its importance.*

Following public and semipublic hygiene, we arrive at what is in many respects the most important subject of all, personal hygiene. It is quite true that the individual is often at the mercy of unclean streets, bad drainage, impure water and food, and other shortcomings of public and semipublic hygiene. On the other hand, his own personal interest is necessary in order to form the public opinion which alone can result in effective public and semipublic hygiene, while that interest is still more necessary to make such hygiene apply directly to his own person. Clean streets are of use only as they make the air breathed purer, but they are of little avail to the household which does not ventilate its rooms or which keeps them in a state of filth. The milk supply of a city may be ideal, but all the pains to make it so will be set at naught if the individual consumer allows the milk to be contaminated after it is delivered. The labeling of foods and drugs will not prevent self-poisoning through alcohol, nor will the elimination of preservatives from foodstuffs and the enforcement of sanitation in their manufacture be of avail if in their preparation for the table they are subjected to disease and dirt. Thus at every point of hygienic progress, there must be individual cooperation with public efforts.

When, contrariwise, health organizations and officials are inefficient, the individual may, in spite of these difficulties, often maintain good health. In New York a woman who was the occupant of a tenement overcame tuberculosis by sitting daily on her fire escape. The air was not the best, but it was much better than indoors. Similar results have been obtained by workmen in Brockton shoe factories, who, in spite of insanitary working places, and without cessation of work, conquered tuberculosis by sleeping on the roofs of their houses at night.

Observation shows that many, possibly most, of the world's most vital men and women have virtually made over their constitutions from weakness to strength. Cornaro, the famous nonogenarian, Kant, and Humboldt are cases typical in different fields of achievement. Cornaro, a Venetian nobleman born about the middle of the fifteenth century and given up to die at the age of 37, foreswore all unhygienic habits and began to live "the temperate life," his abstemiousness applying especially to food. His age at death is variously estimated, but he lived to be at least 97. When over 90 he wrote a treatise on longevity, laying down as the chief rules of a normal life, care in eating and drinking, and the avoidance of melancholy and passion.[a]

Centenarians have usually been persistent followers of some rule or rules of rational hygiene, even though unconsciously.[b]

Metchnikoff points out[c] that part of the supposed inheritance of longevity may not be inheritance, but similarity of environment, and that it very frequently happens that husband and wife both live to be over 100. This could scarcely happen by accident, but must be due to similar habits or environment.

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[a] See L. Cornaro, "The Art of Living Long" (English translation, Wm. F. Butler, Milwaukee), 1903.

[b] Metchnikoff, "The Prolongation of Life," p. 141.

[c] Ibid., p. 86.

Humboldt confessed to a fellow-student that in the first years of his childhood his tutors were doubtful whether even ordinary powers of intelligence would ever be developed in him, and that it was only in the advanced part of his boyhood that he began to show any evidence of mental vigor. As a boy he suffered from debility which not infrequently produced great prostration.[a]

Of recent examples may be mentioned a young physician who was given up to die of tuberculosis five years ago, but who to-day can run 25 miles without a rest; and Horace Fletcher, who in his 46th year was rejected for life insurance, but who later not only obtained his insurance, but proved his powers of endurance by cycling 190 miles on his 50th birthday.

And not only can weakness, if recognized early enough, be turned into strength, but strength, however great, may be dissipated in an incredibly short time.

Personal hygiene means the strengthening of our defenses against disease. Public hygiene seeks to destroy the germs before they reach our bodily defenses. These two branches of hygiene are simply the two forms of warfare, defensive and offensive. Both are of transcendent importance, but the defensive warfare is more within our power. We always have our defending garrison, the white blood corpuscles, to deliver us from our enemies.[b]

SECTION 2—*Branches of personal hygiene.*

Personal hygiene comprises hygiene of environment (air, soil, dwelling, clothing); hygiene of nutrition; and hygiene of activity.

Man is more dependent upon the atmosphere than upon any other environmental factor. His body is bathed in air and his most vital function, respiration, depends upon it. Deprived of air, he will shortly suffocate. If the air is confined and impure, his health will be affected. Ideal air should first of all be pure—i. e., free from injurious bacteria, from dust, smoke, and noxious gases. It should also conform to certain standard conditions of humidity and temperature. In this field lie the sciences of climatology and meteorology. Man learned long ago how to make himself almost independent of climatic and atmospheric conditions by the use of dwellings and clothing. These contrivances, however, while protecting him from the elements, have brought evils of their own. The great scourge of tuberculosis, for instance, is principally an indoor disease.

Intimately related to the appropriation, through the lungs, of oxygen from the atmosphere is the ingestion of food and drink through the alimentary canal. Normal health conditions demand in the case of ingested materials, as in the case of respired air, the greatest possible purity, freedom from injurious bacteria, and the absence of substances hurtful mechanically or chemically.

Finally, the ideal conditions of health require perfect balance of work, play, and sleep.

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[a] "Life of Alexander von Humboldt," by Lowenberg Ave-Lallewort and Dore, translated by Jane and Caroline Lassell, New York (Lee & Shepard), 1873, Vol. I, pp. 30–32.

[b] Metchnikoff, "The New Hygiene," p. 14.

While absolutely perfect conditions in these three branches of hygiene are unobtainable, hygienic progress consists in approaching these ideals as closely as possible.

The rules of personal hygiene are expressed in standard medical works on the subject. There is nothing novel in the brief résumé which follows. The radical changes in habits of living which are now being advocated and to some extent practiced imply nothing new. They have, for the most part, long been commonplaces of the medical profession. The knowledge is old. It is the application which is new. Medical men have long been telling their patients to get plenty of fresh air and to masticate their food. But until recently their advice has fallen on deaf ears.

SECTION 3—*The hygiene of environment.*

Air hygiene deals first of all with ventilation.[a] The importance of properly ventilating houses is so great that to secure this end the architecture of houses will have to be changed. The worst historical instances of bad ventilation are the imprisonment and virtual suffocation of 146 persons in the "Black Hole" of Calcutta and the confinement of 300 men in an underground room after the battle of Austerlitz. The evils of overcrowding come mainly from exhaled air and from the effluvia thrown off by the skin. Not only does overcrowding bring bad air, but it also increases the opportunity for infection.

The air in our houses has impurities of its own. Oil and gas vitiate it. Electric lights are hygienic in this respect. Air is never quite free from dust impurities. Aitkin estimates that country air carries 2,000 dust particles per cubic centimeter, city air 3,000,000, and inhabited rooms 30,000,000.

In a clean hospital ward, when air was agitated by dry sweeping, the number of colonies of bacteria collected on a given exposure rose from 26 to 532, showing the effect of ordinary broom sweeping. The broom is now being replaced by the carpet sweeper, and the carpet sweeper in turn by the vacuum cleaner. Each step represents progress in the elimination of dust. The removable rug is in this regard an improvement over the carpet.

Air may even be poisoned by the chemicals contained in wall paper or in the plaster of a brick and mortar dwelling.

The one place where the individual has more control over the air he breathes than anywhere else is his sleeping room. He may be powerless to control the air in his place of work, or even in the rooms where he lives during the day. But, except where he shares a bedroom with others who are averse to modern ideas of ventilation, he can largely control the air supply during sleep, and this means during one-third of his whole time. He can open wide his windows and in many cases arrange actually to sleep out of doors. The growing practice of sleeping out of doors is one of the most significant signs of the times. Only those who have tried it realize the benefits. The air supply in public places would be under the control of individuals, if organized in protest; and our churches, theaters, public halls, railway coaches, and railway sleepers would be properly ventilated if the public demanded improvement. Such a "score card" as Prof. John R. Commons has devised for measuring the relation of housing conditions to an ideal standard might well be used in measuring the health utility of public places.

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[a] See Richards and Woodman, "Air, Water, and Food," New York (Wiley), 1904; also Carpenter, "Heating and Ventilating Buildings," New York (Wiley), 1905; Sykes, "Public Health and Housing" London (King), 1901, 216 pp.

The windows of living and work rooms may be opened in summer and somewhat in winter, provided a window board is used, to deflect the cold air upward from the sill. It then does not form a cold stratum on the floor, but mixes evenly with the air of the room. This simple device would go far to solve the question of winter shut-ins and their ailments. In many cities sleeping balconies are not uncommon among the dwelling houses.

The many benefits from a pure air supply are only beginning to be realized. For instance, as long as "the outdoor life" is lived a cold is almost impossible. Army officers have noted that as long as the men are on the march and sleep outdoors they hardly ever have colds, but that they become troubled with these as soon as they get indoors. Franklin, a century ago, knew these facts, though few of the present generation are acquainted with them. He believed "that people who live in the forest, in open barns, or with open windows, do not catch cold, and that the disease called 'a cold' is generally caused by impure air, lack of exercise, or from overeating." He came to the conclusion that influenzas and colds are contagious—a doctrine which, a century and a half later, was proved, through the advance of bacteriological science, to be sound. The following sentence exhibits remarkable insight, considering the state of medical art at that time: "I have long been satisfied from observation that besides the general colds now termed 'influenzas' (which may possibly spread by contagion, as well as by a particular quality of the air), people often catch cold from one another when shut up together in close rooms and coaches, and when sitting near and conversing so as to breathe in each other's transpiration; the disorder being in a certain state." In the light of present knowledge what a cautious and exact statement is that.[a]

John Muir, the geologist and naturalist, says that he finds home the most dangerous place he can visit.

> As long as I camp out in the mountains without tents or blankets I get along very well, but the minute I get into a house and have a warm bed and begin to live on fine food, I get into a draft, and the first thing I know I am coughing and sneezing and threatened with pneumonia, and am altogether miserable.

Atmospheric evils come from improper ventilation, and affect either the respiratory organs of the body or the skin. It has been supposed until recently that the presence of carbon dioxid gas in vitiated air was the chief evil caused by such air. Impure air will affect the lungs harmfully, but not till the amount of carbon dioxid contained is very large. Guinea pigs, on which the effects of bad air were observed, were not seriously affected by the carbon dioxid till it amounted to 14 per cent of the volume of the air. Flügge and others have found that the evil of close atmospheres is largely a result of elevated temperature, humidity, and absence of air currents. Tests were made on men who sat in impure air, but breathed pure air through tubes, and they presented all the symptoms usually resulting from bad ventilation.

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[a] From "Benjamin Franklin as Printer and Philosopher," address of President Charles W. Eliot before American Philosophical Association, April 20, 1906.

Air baths have been shown to be as important for bodily health as water baths. For this purpose porous clothing should be worn and no more of it than is needful. Impervious cloth and rubber are probably injurious as clothing. Loosely woven worsteds, or linen and cotton mesh are best adapted to let the air play on the skin. Clothing, to be hygienic, should not constrict the body. Tight shoes, and especially tight corsets, are distinctly injurious, and the injury to mothers from the latter may be felt by the next generation. Another insanitary feature in clothes is the trailing skirt, which drags indoors the sputum of consumptives and germ-laden dirt from the sidewalk.

Closely connected with air and ventilation is light. The benefit of sunshine in killing germs and improving bodily vigor in every way is too well known to need more than mention. Tuberculosis and other germs thrive only in dark, damp, ill-ventilated places.

Light has its most important bearing on the human health through the sense of sight. Its relation to eye strain has been discussed elsewhere. Headaches, backaches, indigestion, hysteria, and epilepsy are often aided by glasses.

SECTION 4.—*The hygiene of nutrition.*

A primary necessity for hygienic living is good drinking water. The modern man of means insists upon good water, and, as a result, the traveling public is now able to get first-class water in cars, hotels, and other public places. The improvement was brought about by the appreciation by the consumer of the danger of drinking impure water. It is the consumer who has it in his power to bring about the necessary reforms in public hygiene. When he really values hygienic environment producers will supply it. Professor Sumner has told us that persons in the middle ages sometimes drank out of their castle moats, which contained sewage. Even in New York to-day the roof tanks are sometimes used as baths or laundries; and they accumulate dust and flies very rapidly. Only a few years ago the aldermen in a prominent western town laughed out of court a physician who called their attention to dangers which were real, but which they believed imaginary, from a polluted water supply.

The scientific study of diet has only just begun and few authoritative results can yet be stated. To avoid a lengthy review of controversial literature it seems best to pass the subject over rapidly, referring the reader for further information to some of the principal books on the subject.

We have already seen the surprising improvement in endurance which followed the adoption of thorough mastication in place of the ordinary food bolting. Mr. Gladstone used to be noted for his care in slowly masticating his food, and latterly Mr. Horace Fletcher has aroused the interest of the public in the subject in Europe and America.[a] He has also stimulated a large number of physiologists to study the subject of mastication, the protein ration, and their relation to strength and endurance.

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[a] See Horace Fletcher, "The A, B–Z of our Own Nutrition," New York (Stokes), 1903; Dr. Hubert Higgins, "Humaniculture," New York (Stokes), 1906; and Irving Fisher, "The Effect of Diet on Endurance," publications of Yale University, Transactions of the Connecticut Academy of Arts and Sciences, 1907.

A great deal has been written as to what foods are best. There exist various dietetic cults, such as vegetarians and fruitarians, raw-food advocates, etc. The question of what foods are ideally best is too large a one to be entered upon here. The evidence seems to point to a general conclusion that no hard-and-fast rule of exclusion is advisable, and that the value of different foods varies with the individual and with his activity, locality, physical condition, etc. His own instinct, restored and educated by avoiding the pernicious habit of food bolting, may be made a truer guide than the wisest physician or physiologist. The same rule applies to the amount of food to be eaten, as well as to the proportions of protein, fat, carbohydrates,[a] and mineral salts. Food bolting often leads to overeating.

It should be noted that the conclusions of Chittenden and others are not in favor of a vegetarian régime, but of a low protein régime, whether vegetarian, lacto-vegetarian, or with flesh foods in moderation. The main point is moderation of the foods highest in protein, such as the whites of eggs and meats (especially lean meats).

It would seem that the safest course for the average man is to follow the appetite, simply guiding it toward a low protein diet by thorough mastication, and by giving the benefit of the doubt to foods low in protein. A reduction in the use of meat will increase, and probably cheapen, our national food supply. The raising of cattle requires much more land than the raising of cereals, fruits, nuts, and vegetables yielding the same amount of food value. As this will be a most important economic problem during the next hundred years, the question of the character of our food supply should be most carefully considered in the study of the conservation of natural resources. It is interesting to note, in this connection, that during the last century the consumption of flesh foods in the United States has considerably decreased.[b]

The subject of auto-intoxication as a consequence of excessive protein has already been mentioned.[c] To avoid auto-intoxication the putrefactive bacteria may be neutralized by lactic bacilli, such as are contained in sour milk. Another preventive is regular attention to thorough evacuation.

Diseased foods are, needless to say, dangerous. Oysters are often planted in waters polluted with sewage, with the result that epidemics of typhoid fever have been traced to their consumption.

The housewife must be the guardian of the family in these respects, and in the cooking, preparation, and arranging of food generally. These now constitute "domestic science," which is justly winning recognition as one of the most potent of all hygienic agencies. When the kitchen becomes a scientifically conducted laboratory we shall have the basis of a sound "home economics."

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[a] For a short method of measuring these magnitudes, see Irving Fisher, "A New Method of Indicating Food Values," American Journal of Physiology, Vol. XV, No. V, April 2, 1906; and for its practical application see "A Graphic Method in Practical Dietetics," Journal American Medical Association, Vol. XLVIII, April 20, 1907. See also, "Statistics of Diet in Consumptive Sanatoria," American Journal Medical Sciences, September, 1906.

[b] See G. K. Holmes, "Meat Supply and Surplus," Bureau of Statistics, Department of Agriculture, Bulletin 55, 1907, p. 47. Mr. Holmes finds that the consumption of dressed meat per capita in the United States decreased between 1840 and 1900, 40 per cent, and between 1890 and 1900, 25 per cent.

[c] Supra, Chap. V. See also Herter's "Common Infection of the Digestive Tract."

SECTION 5.—*Drug habits.*

It would scarcely be an exaggeration to say that the first rule of hygiene is to avoid poisons. Poisons may be generated within us or ingested from without.

Drug habits take numerous forms, and they are more prevalent than most persons realize. The commonest form of intoxication is alcoholic.[a] It is interesting to observe the change which has come about in the attitude of scientists toward alcohol. From having enjoyed a high place in materia medica, it is in danger of being completely discredited.[b] So far as its habitual use is concerned the only question which remains in debate is whether in minute quantities it may be innocuous or even beneficial. In any except minute quantities it has been shown to be injurious.

> It lowers the resistance of the white corpuscles, which are the natural defenders of the body. Although the phagocytes belong to the most resistant elements of our body, yet it is not safe to count on their insensibility toward poisons. It is well known that persons who indulge too freely in alcohol show far less resistance to infectious diseases than abstemious individuals.[c]

Here is the gravest indictment that may be brought against the abuse of alcohol. It is not, however, the only one. The relation of drinking to insanity,[d] peripheral neuritis, Bright's disease, cirrhosis of the liver, inflammation of the stomach, arterioschlerosis (a most common cause of apoplexy),[e] tuberculosis;[f] to crime in all its forms,[g] and to all the possibilities incident to the hereditary transmission of a weakened organism[h] has been pointed out. If personal hygiene is a duty, it is the duty of every man to recognize the danger from alcohol to himself and to his progeny yet unborn. Instead of copying the habits of others, he may consider the responsibility of causing others to copy his.

A subcommittee of the Committee of Fifty for the investigation of the liquor problem published in 1899 a volume on the economic aspects of the problem. The investigation covered a period of about three years and was carried on under the general direction of Prof. Henry W. Farnam, of Yale University. The general conclusions of this investigation were that of the poverty which came under the notice of the charity organization societies about 25 per cent could be traced directly or indirectly to the use of liquor; of the poverty found in almshouses, about 37 per cent. In the investigation of crime, the conclusion was reached that liquor was a first cause in 31 per cent of the criminals studied, and that it entered in as a cause, directly or indirectly, in 50 per cent.

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[a] For a discussion of the physiological effects of alcohol, see Physiological Aspects of the Liquor Problem, investigations made under the direction of W. O. Atwater, John S. Billings, H. P. Bowditch, R. H. Chittenden, and W. H. Welch, subcommittee of the Committee of Fifty; New York, Houghton & Mifflin, 1903, 2 vols.; and The Liquor Problem, a Summary of Investigations Conducted by the Committee of Fifty, 1893-1903, by John S. Billings, Charles W. Eliot, Henry W. Farnam, Jacob L. Greene, and Francis G. Peabody, 1905.

[b] The rôle of alcohol as a predisposing cause of disease has already been noted. It has long been known that drunkards have a very slim chance of recovery when attacked by pneumonia, and it is noted also that the mortality among moderate drinkers is higher than among total abstainers. This fact has long been known to life-insurance companies as holding good for many diseases other than pneumonia. Osler: Modern Medicine, Vol. II, p. 628.

[c] Metchnikoff: The New Hygiene, p. 25.

[d] See "Twenty-sixth Annual Report of Massachusetts Bureau of Labor," 1905.

[e] Ditman, loc. cit., p. 47.

[f] See John Huber, M. D., "Predisposition to tuberculosis," The Medical News, December 26, 1903, p. 12. Also reports of Phipps Institute, Philadelphia.

[g] See Boies's various works, the "Reports of the Committee of Fifty," and Report of the Massachusetts Bureau of Labor Statistics, 1895.

[h] See Henry Smith Williams, M. D., "Alcohol and the Individual," McClure's Magazine, October, 1908, pp. 704-712.

The investigation made by the Massachusetts bureau of statistics of labor in 1895 indicated the following percentages due to alcoholism:

	Per cent.
Crime	84.41
Pauperism	48
Insanity	35

Several English life-insurance companies—the Sceptre, the United Kingdom, and General Provident and others—have found by their statistics, running over forty years, that abstainers have a death rate about 23 per cent lower than nonabstainers.[a] Since the figures of the Mutual Life Insurance Company of New York[b] give the same advantage to American abstainers (23 per cent lower death rate), it seems fair to take the available computations of the English life insurance companies as a basis for estimating the saving of life that would result in the United States if individuals should decide to give up the use of alcohol. It should be remembered, however, that the favorable figure of total abstainers is partly due to the fact that as a class they practice personal hygiene in all its forms.

A basis for computing the sickness that might be saved by total abstinence is furnished by comparison between the sick rates of abstaining and nonabstaining societies, made by Mr. H. Dillon Gouge, public actuary of South Australia, in 1892. He found that the average weeks of sickness in three societies of abstainers was 1.248; in three societies of nonabstainers the average weeks of sickness was 2.317 (lacking only one-sixth of being twice as much).

Absinthe in France has become almost as clearly [illegible]ause of national degeneration as opium in China. Fortunately for our own country there exists here a more determined effort than in most, if not all other nations, to be rid of alcoholism. The movement has been formidable enough to arouse anxiety among those whose capital is invested in breweries, distilleries, and saloons. The movement reaches its maximum momentum in the west and the south of the United States. It is significant of the rapid change of sentiment in regard to the liquor question that physiologists, physicians, educators, and publicists are now becoming so thoroughly impressed with the importance of suppressing the evils of alcohol.

The younger members of the Kaiser's family in Germany are opposed to the German habits in regard to the use of alcohol, and the son of the Kaiser chose for his university one where there was less drinking than at other universities. President Eliot, of Harvard University, has recently taken a strong position against the use of alcohol, even "in moderation."

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[a] Letter from Miss C. F. Stoddard, secretary of the Scientific Temperance Federation.

[b] "Effect of Total Abstinence on the Death Rate," by Joel G. Van Cise, actuary of the Equitable Life Assurance Company of the United States.

Another common, though less injurious, source of self-poisoning is tobacco, which is known to stunt the growth of the young, to lead to sluggishness and weakened hearts ("tobacco hearts"), and to cause dyspepsia and neurasthenia.

Snuff taking has almost disappeared as a habit in this country. Chewing tobacco is still common, though no longer defended by hygienists. "Inhaling" is more common, though also usually condemned on grounds of health. Smoking shows no signs, as yet, of decreasing. In moderation it may not be injurious. There are no definite proofs on either side. But smokers are seldom moderate.

Doctor Seaver, of the Yale Gymnasium, found that of the 187 men in the class of 1891, Yale College, those not using tobacco during the college course had gained over the users of tobacco in weight 32 per cent, in height 29 per cent, in growth of chest 19 per cent, and in lung capacity 66 per cent.[a]

Similar returns for the Amherst graduating class of 1891 showed a gain by the nonusers of tobacco of 24 per cent in weight, of 37 per cent in height, and of 42 per cent in growth of chest. In lung capacity the tobacco users had lost 2 cubic inches of air space, while the nonusers had gained 6⅓ cubic inches.

The somewhat injurious effect of tea, coffee, and condiments, though less than many other evils, should be included in any list of the imperfections in respect to hygiene of existing habits of life.

SECTION 6.—*Activity hygiene.*

Only a generation ago there were scarcely any gymnasia in this country, but to-day the importance of regular exercise and bathing is recognized by everyone. This is far from saying, however, that this important method of conserving our vital resources has more than begun to be exploited.

First, the bath for the well-to-do, and, latterly, the public baths for the poor, have given all an opportunity to obtain the cleansing and healing agency of water. And in recent years the application of baths has become a science.[b]

Baths may be used as social agents. Judge Ben. B. Lindsey, of the Denver juvenile court, insists that every child must take a bath before appearing in the court room. Neutral baths, i. e., baths regulated to the temperature of the body, have been found valuable in relaxing the nerves of the body, and even in the treatment of mental disease.

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[a] Doctor Anderson, of the Yale Gymnasium, finds similar results. He also points out a statistical pitfall into which some investigators have fallen. This is the common statistical fallacy of selection. There are two great groups of college sudents, roughly distinguished as athletes and scholarship men. (See Doctor Sargent, "Physique of scholars, athletes, and the average student," Popular Science Monthly, September, 1908.) Smoking is more common in the former group. They are not athletes because they smoke, but smoke because they are athletes. The raw figures of smokers and nonsmokers usually show that the smokers have better physical development, but if we compare the smoking athletes with the nonsmoking athletes and the smoking scholarship men with the nonsmoking scholarship men the results are quite different. For similar statistical fallacies, due to failure to subgroup properly, see Mayo-Smith, "Statistics and Sociology," Macmillan, 1895.

[b] See J. H. Kellogg, M. D., "Rational Hydrotherapy," Philadelphia, 1904.

As to exercise, a healthy organism must call into play every function daily, both mental and physical. One of the evils of the division of labor which civilization has brought is that the sedentary worker does not have enough physical exercise, but too much mental exercise, while the situation is just the opposite in the case of the workingman.

A well-known physical director, now nearly 50 years old, writes me that he has this year taken up systematic physical training, which he has neglected for several years because of pressure of work. As a result his weight has risen, his chest and arm girths have increased, while his waist girth has decreased, and he is conscious of decided improvement in memory and in sleep. This instance is cited as an example of the physical development possible in a man of middle age.

In its bearing on exercise, the growth of modern athletics and its effects on the physical ideals of men and women is to be welcomed. The revival of the Olympian games and the spread of popular participation in such outdoor sports as golf, tennis, boating, and horseback riding have all had their share in building up a new health ideal. Thus we are getting away from the mediæval idea of mortification of the flesh and approaching more closely the Greek conception of a beautiful body as the covering for a beautiful soul. The Greeks lifted their sports to a higher level than ours by surrounding them with imagination and making them a training in æsthetics as well as in physical excellence.[a] The American idea is at present too closely connected with mere winning, and not enough with development. In the past the physical athlete has been too much associated with the pugilist, and has been looked down upon as having merely brute strength. The intellectual type, on the other hand, has been content wholly to neglect bodily development.

In the last three years considerable evidence has accumulated to show that the sitting posture of the sedentary man tends sooner or later to produce nervous prostration, and that the ordinary chair invites to this effect by producing a bent attitude, both in the forward direction and in the shoulders. The effect of the former is to tax the splanchnic nerves and congest the portal circulation. The splanchnic area, which is enormous, is a sort of overflow tank for the blood. If the muscles of this area are allowed to relax through improper position in standing or sitting, the result is the stagnation of the blood in the abdomen, and this in turn results in a vicious circle of evil effects. Since much of our life is spent in chairs, this fact is of no small importance. Improperly made school chairs and unhygienic habits of sitting in them may start off millions of young lives with round shoulders, curved spines, and the later effects of portal congestion.

Exercise of mind does not simply mean exercise of intellect. The emotions and the will are equally a part of a well-developed healthy man. Late in life Darwin had occasion to lament the fact that his emotional capacity had become cramped because he had exercised his mind in his own branch of work to the exclusion of other things. Whatever our ideas of theology or religion are, it is true that we all ought to have a spiritual sense. Some men lack this spiritual sense and are incapable of understanding the spiritual experience of others. "For toil without purposeful and occupied leisure is unfilled purpose, a process arrested midway."[a] Worry and fear are unhealthy. Hope, courage, enjoyment, and an optimistic attitude generally are healthy.[b]

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[a] See G. L. Dickinson: "The Greek View of Life," New York (McClure, Phillips), 1906, pp. 131–134.

The ordinary workingman works two or three hours too much every day. Nearly every man overworks himself, takes insufficient rest and recreation, and worst of all, cuts off his normal portion of sleep. Fatigue ought to be "avoided like poison," because, physiologically, it is really poison. Worry, fear, and anger also produce poisons harmful to the human body. This is suggested at least by the effect upon a nursing infant of violent paroxysms of anger, or periods of intense fear or anxiety on the part of its mother. The intense exhaustion which follows such paroxysms is another case in point.

An animal lives a much more healthy life than the average man, because an animal follows instinct, while a man to a large extent endeavors to substitute for his instincts rules which are very often false. One of the instincts constantly disregarded by man is that which finds its expression in fatigue. The ordinary man working for some one else is compelled to toil beyond the fatigue limit; and, on the other hand, if a man is in business for himself, he does the same thing of his own will. Although no one knows what sleep is, it serves, according to the best theory, to eliminate poisons and to rebuild tissue. With rest is closely associated recreation. Play practices the power of a child's mind, while contest among children develops self-control.[c] Similarly, adults are rested by play or recreation, their minds and bodies are relaxed, while their contests of mimic warfare develop their powers of will and effort.

SECTION 7.—*Sex hygiene.*

One element in personal hygiene concerns the sex relation. This can not be treated under other heads, for the sex relation is so purely a personal and individual one. From its normal utilization there is little to fear, but from the effects of illegitimate sexual practices the world suffers enormous yearly losses. It is hardly possible to have promiscuous sex relations out of wedlock without contracting one or the other of the serious venereal diseases. The best authorities report that "every prostitute is diseased some of the time and some prostitutes are diseased all of the time."

One disease, syphilis, infects the blood and therewith all parts of the body. For months after infection with this disease the individual may communicate it by a kiss as well as by cohabitation; and articles moistened by his secretions—towels, drinking glasses, pipes, etc.—may also convey the infection. While under proper treatment the disease is not always dangerous to life in the earlier years, yet the possibilities of transmitting the contagion should forbid marriage for at least three years.

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[a] Simon N. Patten: "The New Basis of Civilization," New York (Macmillan), 1907, p. 158.

[b] Du Bois: "The Psychic Treatment of Nervous Disorders," New York, 1905, 465 pp. Saleeby: "Worry, the Disease of the Age," New York (Stokes), 1907. Sidis: "The Psychology of Suggestion," New York (Appleton), 1899, 386 pp. Schofield: "The Force of Mind, or the Mental Factor in Medicine," London (Churchill), 1902, 309 pp.

[c] See President G. Stanley Hall: "Play and Dancing for Adolescents," Independent, reprinted in "Mind and Body," Vol. XIV, 1907, pp. 43-48.

The most serious results of syphilis, some authorities say, may appear years after its acquisition, when the individual has been lulled into a false sense of security by long freedom from its manifestations and considers himself cured. Many cases are practically incurable. Some are fatal in spite of treatment. It may attack any organ of the body. Among the many diseases to which it may lead are apoplexy, paralysis, insanity, and locomotor ataxia; and these often appear after the man has acquired a family that is dependent upon him for support.

The leading insurance companies refuse to insure the life of a syphilitic person for four or five years after the disease was contracted, and then only upon special terms, for their records prove that syphilis shortens life.

That the syphilitic parent may transmit the disease to his offspring is common knowledge. Some of his children are destroyed by the inherited disease before birth; others are born to a brief and sickly span of life; others attain maturity, seriously handicapped in the race of life by a burden of ill health, incapacity, and misery produced by the inherited taint, while still others escape these evil effects.[a]

Forel, in Die Sexuelle Frage, shows that even Weissman does not deny the possibility of poisoning the germ cell and so transmitting some "acquired characteristics," as in alcoholism and venereal poisoning. One of the saddest facts in both cases is that the parent may escape and the children reap the results in insanity, tendency to consumption, and prostitution.

Another disease—

> Gonorrhea, while usually cured without apparent loss of health, has always serious possibilities; it kills about 1 in 200; it impairs the sexual power and fertility of a much larger number; it often produces urethral strictures, which later may cause loss of life.[a]
>
> The persistence of gonorrhea in the deeper parts long after it is outwardly cured leads to the unsuspected communication of the disease to women with whom the individual may cohabit. Much of the surgery performed upon women has been rendered necessary by gonorrhea contracted from the husband. Should she while infected with this disease give birth to a child, the baby's eyes may be attacked by the infection, sometimes with immediate loss of sight. Probably 25 per cent [b] of the blindness of children is thus caused.

Dr. Prince A. Morrow says:

> This social danger comes from frequent introductions of these diseases into marriage. The frequency of marital contamination does not admit of exact mathematical expression, as both social sentiment and professional ethics unite to cover up and conceal it. Possibly 10 per cent of men who marry infect their wives with venereal disease.

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[a] Circular No. 2. "Self-protection," Chicago Society of Social Hygiene, pp. 7–8.

[b] The average of a great many statistics shows that one-fourth of all blind persons owe their affliction to the effects of opthalmia of the new born." Chas. H. May, M. D., ophthalmic and aural surgeon, New York, Transactions of American Societies of Sanitary and Moral Prophylaxis, Vol. II, 1908.

The report of the Committee of Seven (New York) shows that in private practice nearly 30 per cent of venereally infected women were contaminated by their husbands. The report of the Committee on Sanitary and Moral Prophylaxis (Baltimore) shows that nearly 40 per cent of the infections in women seen in private practice were communicated in married life. "My own observations at the New York Hospital, extending over a period of several years, would indicate that fully 70 per cent of all women who came there for treatment of syphilis were respectable married women who had been infected by their husbands.[a]

Observation shows that gonorrhea is markedly intensified in virulence and danger to the woman in fulfilling the functions for which marriage was instituted. Pregnancy and childbearing open the way for germs. One of the most constant effects of gonorrhea in women is permanent and irremediable sterility. Fifty per cent of gonorrheally infected women become absolutely sterile, and a still larger percentage sterile after the first child is born (one-child sterility). Noeggerath found in 81 gonorrheal women 49 entirely sterile. In 80 sterile marriages Kehrer found 45 caused by inflammatory changes of gonorrheal origin. It is estimated that the husband is directly responsible for 20 to 25 per cent of sterility from his inability to procreate as the result of gonorrhea. In addition the husband, though not sterile himself, may infect his wife, rendering her sterile. The disease is ultimately responsible for about 70 to 75 per cent of all sterility in married life, which is not of choice, but of incapacity. Lier-Ascher's careful statistics place this proportion at 71.2 per cent. These figures relate to absolute sterility. The chief social danger of gonorrhea as a depopulating factor is the creation of secondary sterility, or what has been expressively termed "one-child sterility." The large percentage of marriages in which one child represents the total fecundity of the family justifies the conclusion that this sterility is in many cases not of choice, but of procreative capacity extinguished by gonorrhea.[b]

In addition, the inflammation set up in the maternal organs may render the mother a permanent invalid or compel her to submit to a mutilating operation to save her life.

Gynecologists furnish statistical evidence showing that 80 per cent of the deaths due to inflammatory diseases peculiar to women[b] and about 70 per cent[c] of all the work done by specialists for diseases of women is caused by gonorrhea.

In addition to the effect of a low protein diet on endurance, already discussed, and on general health, its relation to the sexual life should be mentioned. Experiments on this subject seem to show that excessive meat eating and excessive protein intake tend to irritate the sexual organs and to produce abnormal sexual desire just as they do a desire for alcoholic stimulation. This fact is of importance in preventing secret vice among the young.

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[a] Morrow, Social Diseases and Marriage, Philadelphia (Lea), 1904.

[b] In report of special committee of the American Medical Association, 1901, Hunniston says: "Ninety per cent of inflammatory troubles of maternal organs are attributable to gonorrhea." Price says: "That in over 1,000 operations for pelvic trouble 95 per cent were attributable to this infection." Another authority gives a percentage of 75.

[c] Address of Doctor Cleveland, president of American Gynecological Society, at National Congress of American Physicians and Surgeons, Washington, 1907.

Thanks to the efforts of a few farsighted men like Dr. Prince A. Morrow, Prof. C. R. Henderson, and Mr. Edward Bok, these subjects are being given some of the publicity they deserve. Reticence on these subjects is justified only so far as it makes for youthful innocence. But ignorance is not innocence; on the contrary it is the surest road to guilt.

SECTION 8.—*Personal hygiene in general.*

Personal hygiene is only beginning to be generally exploited. Most persons leave their health to be attended to by physicians and health officers, just as many people leave their religion in the hands of a priest or clergyman. So far as practiced at all, personal hygiene has been confined chiefly to invalids and athletes. Even by them it is usually practiced to tide over an illness or to prepare for a contest. But it is manifest destiny that a wise economy of vitality will sooner or later be practiced. Waste of vital resources is as irrational as waste of natural resources. Neither is inexhaustible and both must be conserved. Thoughtlessness and ignorance are the reasons for the appalling waste of both now going on. Even people who do not defiantly abuse their strength by definite excesses are liable to waste it gradually. Slightly unhygienic habits grow, and their effects are doubtless cumulative. It is well known that even a so-called "ventilated house," if lived in long enough without sufficient outdoor life, may induce tuberculosis. This must be through the repetition of an infinitesimal injury produced through each respiration eighteen times a minute for twenty-four hours a day for half a lifetime.

So with the use of food preservatives. Food manufacturers have laid much emphasis on the fact that preservatives are "harmless" because used in small quantities, but Doctor Wiley has raised the question whether even very small quantities of these preservatives, if used continuously for a sufficient length of time, are not injurious. The same applies to the repetition of preservatives in a large number of different foods. If only one particular food contained a preservative, the effect would be relatively negligible; but as one food after another has become adulterated, the human stomach is made the daily receptacle of many times the "harmless" amount in any one particular food. The obstacles to hygiene which have accumulated with civilization are almost as numerous and as small as the barnacles which impede a ship. To remove them is in large part to "return to nature." Many of the inventions of which civilization boasts have had an unhygienic side. The invention of houses has made it possible for mankind to spread all over the globe, but it is responsible for tuberculosis, especially after glass was devised, which while letting in the light keeps out the air. The invention of cooking and preparing foods has widened the variety of man's diet, but has led to the decay of his teeth.[a] The invention of the alphabet and printing has made possible the accumulation of knowledge, but it has produced eye strain with all its attendant evils. The invention of chairs has added to human convenience, but has led to spinal curvature and abdominal congestion. The device of a division of labor has added to wealth, but has destroyed the normal balance of mental and physical work, recreation, and rest. Similar fault may be found with clothing, especially corsets, shoes, and hats, and with numerous other contrivances. Yet it would be foolish, even if it were possible, to attempt to "return to nature" in the sense of abolishing civilization. We must not go backward, but forward. The cure for eye strain is not in disregarding the invention of reading, but in introducing the invention of glasses. The cure for tuberculosis is not in the destruction of houses, but in devices for ventilation. It is a little knowledge that is dangerous. Civilization can, with fuller knowledge, bring its own cure and make the "kingdom of man" far larger, even in respect to hygienic conditions, than "nature" people can ever dream of.

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[a] See Ottofy, "The Teeth of the Igorots," Dental Cosmos, July, 1908, where it is shown, statistically speaking, that the teeth of Americans are "ten times as bad as those of the Igorots," while the civilized Filipinos have teeth as bad as those of Americans.

Unhygienic customs and fashions are exceedingly slow to yield, but they do yield in the end. It should be the part of intelligent men to lead in hygienic reform, not by intolerant and impatient abuse of their fellow-men, but by the quiet force of example. The intolerant and impatient reformer does incalculable harm, for he takes no account of that subtle perversity of human nature which resents his interference. Equally harmful is the man who seeks only to imitate the crowd, who condones the vices of his time and country.

But we must always bear in mind what has been called the "psychology of the crowd." Tarde, Le Bon, Baldwin, Ross, and others have shown that society is largely ruled by customs which grow out of imitation. In order that any social custom shall be changed, initiative is necessary. The upper classes should take the lead, for any reform will spread many times more quickly when the initiative comes from above than when it comes from below. Western civilization has made its marvelously rapid progress in Japan for the simple reason that the Mikado approved, and marvelously slow progress in China for the simple reason that the Empress disapproved.

We find the same principle at work in the progress of medicine. Hydrotherapy originated with a peasant and required three centuries to come into vogue. The use of sour milk, on the other hand, has been advocated only during the last two or three years, but the initiative came from Metchnikoff, one of the foremost of medical scientists. The consequence is that the so-called "sour-milk craze" has already led to great industries and affected the business of groceries, soda-water fountains, and even liquor saloons.

The change constituting hygienic reform will be brought about most rapidly by the influences on the young. If children in their homes and schools are given proper models for imitation, the public opinion which they will form may make a revolution in a single generation. Anyone who realizes the almost resistless force of the principle of imitation, especially when applied to children, will receive a new sense of the responsibility he takes in setting an example to the young. There are three classes in particular on whom the responsibility is heavy—teachers, physicians, and parents. If they wish the child to be free from the cigarette habit, they must sacrifice the cigar and pipe habit, even though it be true that cigars and pipes are not injurious to adults. They may believe this, but the children will not. The same principle applies to other and more serious infractions of the laws of health. It is probably through the love of the next generation, rather than through any selfish care for the present, that men and women now living will take the most pains to secure the best results in bringing about the change in living conditions for which every hygienist hopes.

CHAPTER X.—*Are hygienic measures eugenic?*

SECTION 1.—*Prolongation of weak lives.*

We have discussed two factors which cooperate to produce vitality, namely, heredity and hygiene; and two corresponding methods of improving vitality, namely, by utilizing a possible science of eugenics on the one hand and by utilizing the existing science of hygiene on the other. The question now arises, Are these two methods in conflict with each other? It is charged that hygiene prolongs the lives of unfit and defective classes. We have already seen that in Indiana, institutional care of the insane has prolonged the average insane lifetime by some eight years. Referring to the insane, Dr. Charles Dana says:

> For twenty-five years the explanation of this increase in statistics of insanity has been that more cases were observed and more victims kept in institutions than formerly; and this is still the explanation. It is my opinion, however, that the increase is a real one, and it is one to be expected not only from the strenuousness of modern life and increase of city population, but also, because more feeble children are nursed to maturity and more invalid adolescents are kept alive to propagate weakly constitutions or to fall victims themselves to alienation, the period of life susceptible to insanity is longer.
>
> A fourth of the cases of insanity is due to so-called "moral causes:" Emotional strain, shocks, and vicious indulgences. But moral causes are not sufficient to cause insanity if the individual has a strong constitution. Insanity is increased in part, then, because we are saving too many lives by the careful regulations of our health boards. Hence, those who are working so enthusiastically and nobly and successfully in preventing disease achieve results which carry serious responsibilities for the State.[a]

It is true that we prolong the lives of the insane and defective classes, and that they thus make a greater burden on society. We should see to it that certain of these classes are not permitted to propagate their kind. This point has been explained in Chapter VI.

It is further claimed that infant mortality is but the operation of natural selection and should not be interfered with if we are to keep up the vital power of the race. Preventive medicine has certainly prolonged the lives of infants or, at any rate, of children in general.[b] But has this weakened the race? It is pointed out that the mortality later in life has not decreased, and that in some cases it has even tended to increase. But this fact can be explained in either of two ways. One is on the hypothesis of the extension of the lives of weak infants. The other is on the hypothesis of the comparative neglect of hygiene among adults. It is surprising that this latter alternative has not been given due consideration.

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[a] "Psychiatry in its relation to the other sciences," by Charles L. Dana, M. D., before the section on psychiatry at the International Congress of Arts and Science, at St. Louis, September, 1904. See also Janus in Modern Life, by W. M. Flinders Petri, New York (Putnam), 1907.

[b] See Edwin Graham, "Infant mortality," Journal American Medical Association, September 26, 1908; also Edward B. Phelps, "Statistical study of infant mortality," Quarterly Publications American Statistical Association, September, 1908. Mr. Phelps shows that infant mortality has declined less than is commonly believed, and that its apparent decline is often due to inaccurate and misleading statistics.

Every detail of infant life has latterly been made the subject of special study, and every mother of common intelligence has tried to learn and to apply the results of that study. The times of the baby's meals, the quantity of its feeding, the modification and sterilization of cow's milk, the hours of sleep, the ventilation of sleeping rooms, and other innumerable details are now attended to with scrupulous care. The change in these respects, even within the memory of most persons now living, is striking. The children have reaped the reward. But no corresponding change has taken place in the habits of the adult population. Many families buy one grade of milk for the babies, and another cheaper grade for the rest of the family. This they regard as "economy." Parents require their children to keep regular and suitable hours for sleep, but "owl it" themselves. They will keep their children out of doors, and send them into the country, but subject themselves to the dust, smoke, and close air of the workroom and places of business. They will not allow their children to use alcohol or tobacco, or even tea or coffee, much less opium, chloral, or other habit-forming drugs, but they take these themselves as a matter of course. They are now insisting on playgrounds for children, but their own amusements are sought in the unhygienic theater, or maybe in the saloon or immoral resort. The child is protected on all sides, with the result that he sometimes lives almost an ideal animal life, with its due proportion of amusement, exercise, rest, and sleep. The parents themselves are tied down to drudgery, overwork, worry, and long hours. The difference, when we reflect upon it, is startling. We make hygiene paramount for our children; for ourselves we neglect it totally, partly from the idea of sacrificing ourselves for the sake of our children, partly from necessity, real or imagined, and partly from the thraldom of habit already formed. With such a contrast between the recent improvement of hygiene in childhood and the lack of improvement in middle life, one need not wonder that the mortality of one period has improved and that of the other has not. We do not need to invoke the aid of the theory that weak lives have been more prolonged than strong lives. The moral is that hygiene should not stop in childhood. It is natural and proper, however, that the first attempt to apply hygienic knowledge should begin with children. It is through children that new ideas usually make their way into custom. "You can't teach an old dog new tricks." Grown persons have habits already formed, and when once a habit is formed it is difficult to change it.

Habits of living among adults have even grown worse in some respects. Observing practitioners comment on the increasing nervous tension in modern life. The rush of the railway train, the telephone, the elevator are at once an outgrowth and an excitant of this increased tension. They are life's pace makers, and the pace is ever quickened. The health officer of New York City attributes to this severer strain the increase of heart and nervous diseases. It would be interesting to know the relative prevalence of adult diseases under conditions of reposeful and exciting surroundings and occupations, but I know of no investigation on this phase of the subject.

While this report was being written the recent figures from Great Britain came to hand. They show that the tendency of the death rates among the later ages to increase seems to have given place to a slightly opposite tendency. The expectation of life at ages 40, 60, and 80 during the decade of 1891–1900 has a little more than held its own as compared with the previous decade.

SECTION 2.—*Children's diseases impair both fit and unfit.*

Another point needs emphasis. When it is said that the lives of weak infants are prolonged it is commonly overlooked that the same causes also prolong the lives of the strong, and, reversely, that unhygienic conditions which tend to exterminate the weak tend also to shorten the lives of the strong. Bad hygiene is merely a common handicap for all classes. The burden of proof is upon those who claim that it has a differential effect and increases the process of weeding out the unfit. This weeding-out process goes on whether there is a great or a small obstruction to overcome. Bad air and children's epidemics are the common environment of all. While this must produce a greater mortality, it remains to be shown that it would be more selective.

That a high infant mortality does not tend to lengthen life, but rather to stunt all life, would seem to be indicated by the evidence, so far as it can be interpreted. Russia, for instance, has a high infant mortality. If the statistics are to be trusted, it is 70 per cent greater than in the United States; yet Moscow and St. Petersburg have a general mortality rate which greatly exceeds that of similar cities in this country.

It may be that the more unfavorable the struggle for existence the more rapidly will natural selection result in improved vitality. But even if this were true, it would not imply that in a more favorable environment selection would cease. And it may not be true. It may be that adversity, if too severe, will crush and injure the survivor as well as eliminate the unfit. We do not look for the best trees on the bleak mountain top, but in the genial valley. As we go up the struggle for existence increases, until even the sturdiest fail to thrive above the "timber line."

> The farmer who tries to improve his stock does not select hardships. Cold and starvation are now negligible quantities in the great ranches, and the breeds that were notable for ability to withstand them give way to varieties that may be adapted to neither emergency.[a]

Venereal diseases, hook-worm disease, malaria, and many other maladies shorten and weaken life, whether of weak or strong. Referring to the racial degeneration probably caused by malaria on the sturdy Greek, Maj. Ronald Ross said, in an address before the Oxford Medical Society, November 29, 1906:[b]

> Now what must be the effect of this ubiquitous and everlasting incubus of disease on the people of modern Greece? Remember that the malady is essentially one of infancy among the native population. Infecting the child one or two years after birth, it persecutes him until puberty with a long succession of febrile attacks. * * * Imagine the effect it would produce upon our own

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[a] Simon N. Patten, The New Basis of Civilization, New York (Macmillan), 1907.

[b] This quotation is from Dr. L. O. Howard's report to the Conservation Commission on "Economic loss to the people of the United States through insects that carry disease."

> children here in Britain. * * * What would be the effect upon our population, especially our rural population—upon their numbers and upon the health and vigor of the survivor? It must be enormous in Greece. People often seem to think that such a plague strengthens a race by killing off the weaker individuals; but this view rests upon the unproven assumption that it is really the weaker children which can not survive. On the contrary, experience seems to show that it is the stronger blood which suffers most—the fair, northern blood which nature attempts constantly to pour into the southern lands.[a] If this be true, the effect of malaria will be constantly to resist the invigorating influx which nature has provided; and there are many facts in the history of India, Italy, and Africa which could be brought forward in support of this hypothesis. * * * In prehistoric times Greece was certainly peopled by successive waves of Aryan invaders from the north. * * * That race reached its climax of development at the time of Pericles. * * * Suddenly, however, a blight fell over all. Was it due to internecine conflict or to foreign conquest? Scarcely, for history shows that war burns and ravages, but does not annihilate. Thebes was thrice destroyed, but thrice rebuilt. Or was it due to some cause, entering furtively and gradually sapping away the energies of the race by attacking the rural population, by slaying the newborn infant, by seizing the rising generation, and especially by killing out the fair-haired descendant of the original settlers, leaving behind chiefly the more immunized and darker children of their captives, won by the sword from Asia and Africa? * * * I can not imagine Lake Kopais, in its present highly malarious condition, to have been thickly peopled by a vigorous race; nor, on looking at those wonderful figured tombstones at Athens, can I imagine that the healthy and powerful people represented upon them could have ever passed through the anæmic and "splenomegalous" infancy (to coin a word) caused by widespread malaria. Well, I venture only to suggest the hypothesis, and must leave it to scholars for confirmation or rejection. Of one thing I am confident—that causes such as malaria, dysentery, and intestinal entozoa must have modified history to a much greater extent than we conceive.

Evolution in human society is a wonderfully complex thing. Survival of the races has long been dependent on a long period of protection of children by parents, and may in future even depend on protection of other kinds.[b]

SECTION 3.—*Fitness is relative to environment.*

Whether or not degeneration is actually going on is a question for which the data are insufficient for us to form an intelligent generalization. That there are very strong forces working in that direction can not be questioned, but there are also very strong forces working in the opposite direction. In discussing degeneration, one point must be borne in mind which has often been forgotten by writers on the subject. Man's fitness to live is relative to the environment in which he is to live. If muscular strength decreases, it is not a sign of degeneration, provided muscular strength is no longer needed. One does not speak of hothouse grapes as degenerates. They doubtless lack the hardy characteristics of wild grapes, but these characteristics are not needed in a hothouse.

If it should prove true that in some directions humanitarian impulses betray us into favoring the survival of the unfit and their perpetuation in the next generation, such shortsighted kindness must be checked. But all the dangers of perpetuating vital weaknesses can be avoided if proper health ideals are maintained. For when such health ideals become a national possession fewer weak infants will be born into the world. This will come about in three ways: First, marriage and "sterilization" laws will reduce the number of marriages of degenerates. Secondly, parents will be more careful of transmitting disease or weakness to their offspring. There is strong reason to believe that inheritance depends largely upon the physical condition of both parents at the time of conception. If at such a time either parent, or both parents, are in a state of intoxication or sufferers from venereal disease, this lack of hygiene on their part will affect the heredity of the offspring. Immorality, which practically means lack of sex hygiene, never strengthened a race; on the contrary it has been the most potent cause of race extinction (of the Hawaiians, Indians, negroes, and others).[a] Thirdly, the influence of higher ideals of health and vitality will tend both to restore the attraction of a strong and beautiful physique to its rightful place among the various attractions which lead to marriage, and to lessen the allurements of such extraneous attractions as wealth.

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[a] Physicians maintain that some diseases, especially typhoid fever and pneumonia, are more apt to attack the strong than the weak.

[b] See Prince Kuropatkin, "Mutual Aid a factor in Evolution," New York (McClure-Phillips), 1902.

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[a] See F. L. Hoffman, "Race Traits and Tendencies of the American Negro," Publication of American Economic Association, Ch. VII. August, 1896.

Part IV.—RESULTS OF CONSERVING LIFE.

CHAPTER XI.—*Prolongation of life.*

SECTION 1.—*Life is lengthening.*

We have already seen evidence of the possibility of prolonging life: In Europe the life span is double what it is in India. The death rate of Dublin is over twice that of Amsterdam, and three times that of rural Michigan. Again, making every allowance for inaccuracies of old records, we have strong reason to believe that life is twice as long as three or four centuries ago, and modern accurate records show that it is to-day increasing more rapidly than ever. The rate at which this lengthening proceeds per century is shown in the following table, based on Chapter I.

Rate of lengthening life (in years, per century).

Country.	Periods.	Males.	Females.
England	1838-1854 to 1871-1881, or 30 years	5	9
Do.	1871-1881 to 1891-1900, or 20 years	14	16
France	1817-1831 to 1898-1903, or 76 years	10	11
Prussia	1867-1877 to 1891-1900, or 23 years	25	29
Denmark	1835-1844 to 1895-1900, or 57 years	13	15
Sweden	1816-1840 to 1891-1900, or 67 years	17	15
United States:			
Massachusetts.	1789 to 1855, or 66 years	7	
Do.	1855 to 1893-1897, or 40 years	14	
India	1881 to 1901, or 20 years	0	

From this table we observe:

First. That the rate of progress is extremely variable in different countries. It is perhaps no accident that the maximum rate obtains in Prussia, which is probably the most progressive country in the discovery and application of scientific medicine. If progress continues for a century at merely the present rate, human life in Prussia will be twenty-five to twenty-nine years longer than at present. The average rate of improvement for all the countries, excepting India, is about fifteen years per century.

Second. It is noticeable that in practically all cases the improvement is more among females than males. This is one expression of the progress which womankind is now making in all lands.

Third. This table, as well as the estimate of Professor Finkelnburg already quoted, shows that not only is the average duration of human life increasing, but that the rate of increase is also increasing. The estimate of Finkelnburg that the lengthening of life during the interval between the sixteenth century and the end of the eighteenth century was from eighteen or twenty years to a little over thirty years shows a rate of increase of about four years per century. During the following century he estimated that the life span increased from a little over thirty to thirty-eight or forty years, or about nine years per century. In the table we see that in England the length of life was increasing in the middle of the nineteenth century at a rate of from five to nine years per century, while during the last quarter it was increasing at from fourteen to sixteen years per century. In Massachusetts the imperfect data indicate that life lengthened in the first half of the eighteenth century at the rate of about seven years a century. The indication for the last part of the nineteenth century is that it increased at the rate of fourteen years per century.

We may briefly summarize chronologically the general rate of increase as follows:

Lengthening of human life per century.

	Years.
During seventeenth and eighteenth centuries	4
During first three quarters of the nineteenth century	9
Present rate in Massachusetts	14
Present rate in Europe	17
Present rate in Prussia	27

SECTION 2.—*Table showing further practicable prolongation.*

It would be surprising if the future should not witness a further lengthening of human life, and at an increasing rate. Of course there is a limit to the further increase of human life, but there is good reason to believe that the limit is still far off.

The following table[a] shows that at least fourteen years could be added to human life by the partial elimination of preventable diseases according to the stated ratios of preventability. This is equivalent to a reduction in the death rate of about 25 per cent. The table is based on the causes of death given in the census volume for mortality statistics for 1906. These causes are arranged according to the average, or rather median,[b] age at death from the disease. This median age is given in the second column. The order in this column shows at a glance the successive onslaught of, or rather fatality from, the various causes of death. The table shows the successive bombardments of disease to which human life is subject.

The third column gives the average lost "expectation of life;"[c] that is, the expectation cut off by each particular cause of death.

The fourth column represents the percentage which the deaths from each particular cause bear to the total number of deaths in 1906 in the registration area. It shows the relative importance of the different causes of death in the present death rate, but has no reference to the age at death.

The fifth column contains an estimate, made by physicians, of the ratio of preventability of deaths from each cause named.

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[a] For detailed statement in regard to the construction of this table, see appendix to this chapter.

[b] By the "median" age at death is meant the age such that one-half of the deaths occur earlier and one-half later than this age. The "median" is a species of average, but differs from the ordinary arithmetical average. It has the great advantage of ease of computation.

[c] The "expectation" is taken from the figures of Abbott for Massachusetts, 1893–1897, and is the average of expectation of males and females. See Report State Board of Health for Massachusetts, 1898.

The items in the sixth column are found by multiplying together those in the fourth and fifth columns, and express the percentage which the preventable deaths from each cause named bears to the total number of deaths from all causes.

The seventh and last column gives the figures for which the table is constructed, namely, the amount of prolongation of life which would come about through preventing deaths according to the ratios of preventability in column 5. When it is said that a death is preventable, it is not, of course, meant that the person saved from it will never die, but merely that his death is postponed. The term "postponable" would avoid a great deal of confusion on the subject.

The principle on which the last column is constructed is simply the principle of averages. The column shows the prolongation of life which would be caused by postponing the "postponable" deaths by the amounts indicated in column 3. To illustrate this principle, suppose ten magnitudes to be averaged arithmetically, and that their average is thirty. To fix our ideas, we may suppose these ten magnitudes to be represented by ten lines drawn on a sheet of paper. It is evident that if one of these ten lines is prolonged the average of the ten will be thereby increased by exactly one-tenth of the prolongation of that one line.

Possible prolongation of life.

(1)	(2)	(3)	[b](4)	(5)	(6)	(7)
	A.	B.	C.	D.	E=CD.	F=BE.
Cause of death.	Median age of deaths from causes named.	Expectation of life at median age.	Deaths due to cause named as percentage of all deaths.	Ratio of preventability (postponability), i. e., ratio of "preventable" deaths from cause named to all deaths from cause named.	Ratio of "preventable" deaths from cause named to all deaths from all causes.	Years added to average lifetime if deaths were prevented in the ratio of preventability of column 5.
	Years.	*Years.*	*Per cent.*	*Per cent.*	*Per cent.*	*Years.*
1. Premature birth	1	50	2	40	0.8	0.4
2. Congenital malformation of heart (cyanosis)	1	50	.55	0	....	....
3. Congenital malformations other than of heart	1	50	.3	0	....	....
4. Congenital debility	1	50	2.3	40	.92	.46
5. Hydrocephalus	1	50	.1	0	....	....
6. Venereal diseases	1	50	.3	70	.21	.11
7. Diarrhea and enteritis	1	50	7.74	60	4.64	2.32
8. Measles	1	50	.8	40	.32	.16
9. Acute bronchitis	1	50	1.1	30	.33	.17
10. Broncho-pneumonia	1	50	2.4	50	1.2	.6
11. Whooping cough	1	50	.9	40	.36	.18
12. Croup	2	54	.3	75	.22	.12
13. Meningitis	2	54	1.6	70	1.12	.6
14. Diseases of larynx other than laryngitis	3	54	.07	40	.03	.02
15. Laryngitis	3	54	.06	40	.02	.01
16. Diphtheria	3	54	1.4	70	.98	.53
17. Scarlet fever	3	54	.5	50	.25	.14
18. Diseases of lymphatics	5	54	.01	20	.002	.001
19. Tonsilitis	8	52	.05	45	.02	.01
20. Tetanus	8	52	.19	80	.15	.08
21. Tuberculosis other than of lungs	23	40	.17	75	.13	.05
22. Abscess	24	39	.08	60	.05	.02
23. Appendicitis	24	39	.7	50	.35	.14
24. Typhoid fever	26	38	2	85	1.7	.65
25. Puerperal convulsions	28	[a]37	.2	30	.06	.02

[a] "Expectation" for females.

[b] As to some inaccuracies in this column, see Appendix to this chapter, section 4.

Possible prolongation of life—Continued.

(1) Cause of death.	(2) A. Median age of deaths from causes named.	(3) B. Expectation of life at median age.	(4) C. Deaths due to cause named as percentage of all deaths.	(5) D. Ratio of preventability (postponability), i. e., ratio of "preventable" deaths from cause named to all deaths from cause named.	(6) E=CD. Ratio of "preventable" deaths from cause named to all deaths from all causes.	(7) F=BE. Years added to average lifetime if deaths were prevented in the ratio of preventability of column 5.
	Years.	*Years.*	*Per cent.*	*Per cent.*	*Per cent.*	*Years.*
26. Puerperal septicemia	28	[a]37	0.4	85	0.34	0.13
27. Other causes incident to childbirth	31	[a]35	.36	50	.18	.06
28. Diseases of tubes	31	[a]35	.1	65	.06	.02
29. Peritonitis	31	34	.5	55	.28	.1
30. Smallpox	32	34	.01	75	.01	.003
31. Tuberculosis of lungs	33	33	9.9	75	7.42	2.45
32. Violence	34	32	7.5	35	2.7	.86
33. Malarial fever	34	32	.2	80	.16	.05
34. Septicemia	34	32	.3	40	.12	.04
35. Epilepsy	35	32	.29	0	......	......
36. General, ill defined, and unknown causes (including "heart failure," "dropsy," and "convulsions")	35	31	9.2	30	2.75	.85
37. Erysipelas	37	30	.3	60	.18	.05
38. Pneumonia (lobar and unqualified)	37	30	7	45	3.15	.94
39. Acute nephritis	39	29	.6	30	.18	.05
40. Pleurisy	42	27	.27	55	.15	.04
41. Acute yellow atrophy of liver	42	27	.02	0	......	......
42. Obstruction of intestines	43	26	.6	25	.15	.04
43. Alcoholism	44	25	.4	85	.34	.09
44. Hemorrhage of lungs	45	25	.1	80	.08	.02
45. Diseases of thyroid body	46	24	.02	10	.002	.0005
46. Ovarian tumor	46	[a]25	.07	0	......	......
47. Uterine tumor	46	[a]25	.1	60	.06	.02
48. Rheumatism	47	23	.5	10	.05	.01
49. Gangrene of lungs	48	23	.03	0	......	......
50. Anemia, leukemia	48	23	.4	50	.2	.05
51. Chronic poisonings	48	23	.05	70	.03	.007
52. Congestion of lungs	49	22	.4	50	.2	.04
53. Ulcer of stomach	49	22	.2	50	.1	.02
54. Carbuncle	49	22	.03	50	.015	.003
55. Pericarditis	52	20	.1	10	.01	.002
56. Cancer of female genital organs	52	[a]21	.6	0	......	......
57. Dysentery	52	20	.5	80	.4	.08
58. Gastritis	53	19	.65	50	.32	.06
59. Cholera nostras	53	19	.09	50	.05	.01
60. Cirrhosis of liver	54	19	.9	60	.54	.1
61. General paralysis of insane	55	18	.3	75	.22	.04
62. Hydatid tumors of liver	55	18	.002	75	.002	.0003
63. Endocarditis	56	17	.8	25	.2	.03
64. Locomotor ataxia	56	17	.17	35	.06	.01
65. Diseases of veins	57	17	.04	40	.02	.003
66. Cancer of breast	58	[a]17	.4	0	......	......
67. Diabetes	58	16	.8	10	.08	.01
68. Biliary calculi	58	16	.17	40	.07	.01
69. Hernia	59	16	.27	70	.19	.03
70. Cancer not specified	59	16	.9	0	......	......
71. Tumor	59	16	.08	0	......	......
72. Bright's disease	59	16	5.6	40	2.24	.36
73. Embolism and thrombosis	60	15	.26	0	......	......
74. Cancer of intestines	60	15	.5	0	......	......
75. Cancer of stomach and liver	61	14	1.7	0	......	......
76. Calculi of urinary tract	61	14	.03	10	.003	.0004
77. Cancer of mouth	63	13	.1	0	......	......
78. Heart disease	63	13	8.1	25	2.02	.26
79. Influenza	64	13	.7	50	.35	.05
80. Asthma and emphysema	64	13	.23	30	.07	.009
81. Angina pectoris	65	12	.4	25	.1	.01
82. Apoplexy	67	11	4.4	35	1.54	.17
83. Cancer of skin	70	10	.2	0	......	......
84. Chronic bronchitis	71	9	.8	30	.24	.02
85. Paralysis	71	9	1	50	.5	.04

[a] "Expectation" for females.

Possible prolongation of life—Continued.

(1) Cause of death.	(2) A. Median age of deaths from causes named.	(3) B. Expectation of life at median age.	(4) C. Deaths due to cause named as percentage of all deaths.	(5) D. Ratio of preventability (postponability), i. e., ratio of "preventable" deaths from cause named to all deaths from cause named.	(6) E=CD. Ratio of "preventable" deaths from cause named to all deaths from all causes.	(7) F=BE. Years added to average lifetime if deaths were prevented in the ratio of preventability of column 5.
	Years.	*Years.*	*Per cent.*	*Per cent.*	*Per cent.*	*Years.*
86. Softening of brain	71	9	0.2	0	....	....
87. Diseases of arteries	73	9	0.83	10	0.08	0.007
88. Diseases of bladder	74	8	0.2	45	0.09	0.007
89. Gangrene	74	8	0.25	60	0.15	0.01
90. Old age	83	5	2	0	....	....
All causes	38	....	100	42.3	[a]42.3	14.06
RÉSUMÉ.						
Diseases of infancy (having median age 1)	....	....	18.5	47	8.8	4.4
Diseases of childhood (having median age 2 to 8)	....	....	4.2	67	2.8	1.51
Diseases of middle age (having median age 23 to 49)	....	....	43	49	21.2	6.82
Diseases of late life (having median age 52 to 83)	....	....	34.3	28	9.5	1.33
All causes	....	....	100	42.3	42.3	14.06

[a] Although this is the ratio of general preventability of deaths under existing conditions, the death rate, i. e., deaths in relation to population, will not in the end be affected in this ratio but by only about 25 per cent. The reason for this paradox is that deaths prevented lead to a larger population (See appendix to this chapter, section 3).

Similarly, if of the ten lines three are prolonged each a certain stated amount, or are prolonged that amount on the average, the average of the whole ten will be increased by three-tenths of this amount. Consequently, if the saved lives from typhoid fever (No. 24 in the table) are, on an average, prolonged thirty-eight years, and these saved lives represent 1.7 per cent of all lives, the average life will be prolonged by 1.7 per cent of thirty-eight years. This is 0.65 or two-thirds of a year.

All the calculations are on the assumption of expectations of life, such that the saved lives will die according to the present law of mortality. Consequently, if the table should be corrected by substituting in each case such an expectation of life as would conform to the improved mortality, the result would be an addition (2.1 years)[a] to the estimate of possible prolongation, which would therefore become 16.2 years. The résumé of the table shows that of the 14 years of possible prolongation of life 4.4 would be caused by reducing infant deaths under or near 1 year, 1.51 by reducing mortality from children's diseases, 6.82 from reducing the diseases of middle life, especially tuberculosis and typhoid, and only 1.33 by reducing the mortality of diseases the deaths from which usually come after 50 years of age.

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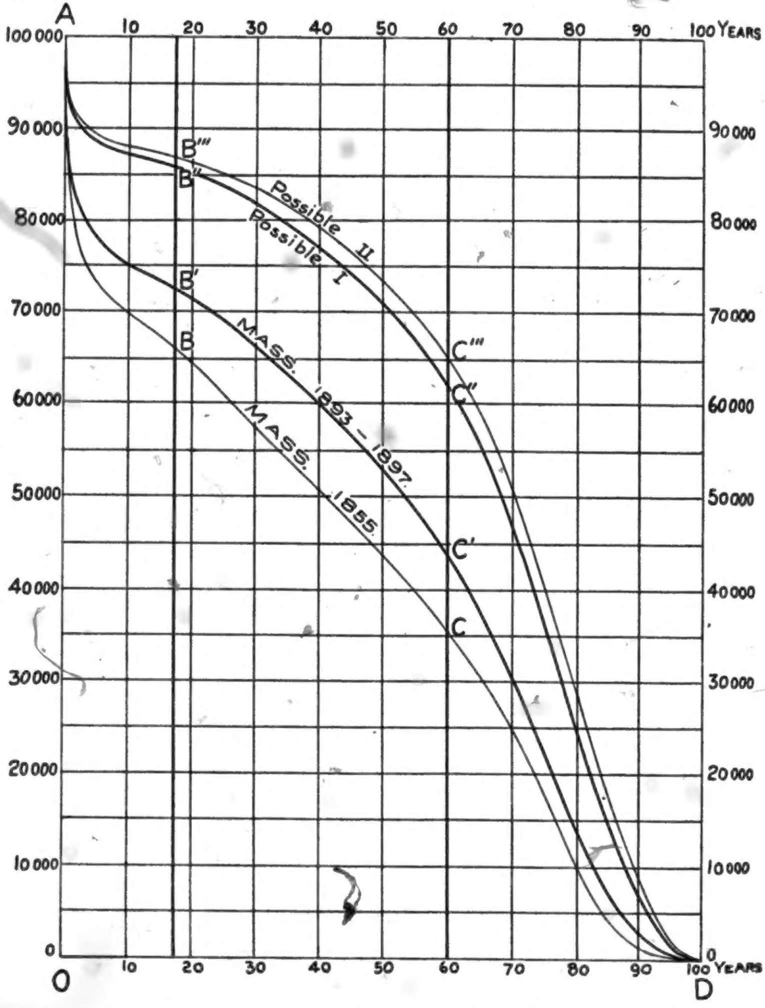
[a] Best estimated graphically, as shown in appendix to this chapter.



SURVIVORSHIP CURVES, SHOWING SAFE MINIMUM IMPROVEMENT ATTAINABLE.

The table shows that seven of the 90 causes of death are responsible for over half of the shortening of life, namely, diarrhea and enteritis (No. 7), broncho-pneumonia (No. 10), meningitis (No. 13), typhoid (No. 24), tuberculosis of lungs (No. 31), violence (No. 32), and pneumonia (No. 38). These alone shorten life needlessly by more than eight years. Against these seven causes, therefore, our special efforts should be directed. Pure milk, pure water, pure air, and reasonable protection from accident are the chief means known at present. When the public makes up its mind no longer to endure impure milk, impure water, and impure air, and unreasonable dangers to life and limb, life will lengthen eight years, and probably a great deal more.

In the résumé of the table columns 4, 6, and 7 are found from the original table by simple addition. Each figure in the fifth column is found by dividing the figure in the sixth by that in the fourth.[a]

The final figure in this column, 42.3, is the same as the sum of column 6, and means that according to medical opinion 42.3 per cent of the deaths which occur under present conditions are preventable (postponable). The death rate, however, will ultimately be reduced, not in this proportion, but by about 25 per cent,[b] while the average duration of life will be increased about 33⅓ per cent.

SECTION 3.—*Diagram showing effect of prolongation at different ages.*

The whole process is best seen by means of a survivorship table, a diagram of which follows:

We have here four curves which represent the survivors in successive years from a hypothetical and representative list of 100,000 persons born. The two of these curves which should be noted are the inner two, namely, those labeled "Mass. 1893–97" and "Possible I." The former is taken, in lieu of any better statistics, as representing the existing law of mortality in the United States. The latter shows what the law of mortality would be if the ratios of preventability given in the preceding table were put in force. The curve Possible I is constructed on the supposition that all the deaths prevented or postponed subsequently occur according to the present law of mortality; that is, that expressed in the curve Mass. 1893–97.

The two remaining, or outer, curves are given merely for comparison. The lowest, marked "Mass. 1855," shows the mortality which held true in Massachusetts in that year according to the estimates of the actuary, E. B. Elliott.[c] The difference between this curve and the one above shows the number of years of life actually saved to 100,000 persons subject to the mortality of 1893–1897 instead of the mortality of 1855. The upper curve (Possible II) shows the modification in Possible I on the assumption that the saved lives, instead of following the present law of mortality (Massachusetts,

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[a] The result is in each case a weighted average of the individual ratios of preventability for the individual causes of death.

[b] See appendix.

[c] See Proceedings of the American Association for the Advancement of Science, 1857, pp. 61, 69; also Sixteenth Registration Report, Massachusetts, 1857, p. 204.

1893–1897), follow the law of mortality represented in the curve Possible II itself.[a]

This diagram shows at a glance what improvement has been made in mortality and at what ages, and what improvement is still possible, and at what ages, according to the preventability known to be easily possible. We see that the curve, Possible I, does not drop as far in the first year of life as the curve Mass. 1893–97. This is because of the great saving of infant lives known to be possible. The years of life which would be saved to the 100,000 persons by the new hygiene are represented by the difference in area between the new curve AB″C″D and the old curve AB′C′D, from which it was constructed by applying the ratio of preventability. This area can easily be measured by a planimeter, and is found to be 1,280,000, which, divided by the 100,000 persons, means an average addition of 12.8 years to the lifetime of each person born. This result differs somewhat from the arithmetical calculation, 14.06, given in the preceding table.[b] If the upper curve be used, which assumes that the "saved" lives die not according to the old but the new mortality, the addition becomes not 12.8 but 14.9 years, as against the 16.1 computed arithmetically. We may hereafter refer to this minimum estimate of possible increase of life as, in round numbers, 15 years. The lengthening of life would be from 45 to 60, or one-third.

The diagram also shows the saving of life which actually took place between 1855 and the period 1893–1897. The area between the curves for these two periods shows that 550,000 years were saved for a supposed group of 100,000 persons, or 5.5 per person. The whole area of the new curve AB″C″D is 5,810,000, or 58.1 years per person, which is the new average duration of life, as compared with 45.3 for 1893–97 and 39.8 years for 1855. We may divide the diagram by two vertical lines drawn at the ages 17½ and 60 in order to discover what part of the added life occurs between these ages—that is, within the working period—and what parts fall on either side. The addition of 12.8 years to the lifetime of each of 100,000 persons, or 1,280,000 years of life in all, is divided into three groups, namely, the years falling in the period of preparation, 200,000; in the working period, 680,000; in the period of decline, 400,000. The following table will show the whole process:

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[a] The method of constructing the curves Possible I and Possible II from the curve Mass. 1893–97 is by means of the ratios of preventability given in the résumé of the preceding table. See appendix.

[b] The discrepancy, 1.3 years, is due to the fact that in constructing the table, based on individual diseases, I was compelled to use for the percentages of deaths by ages (column 4) the percentages obtaining in the calendar year 1906; whereas the diagram is based on the idea of a stationary population, the distribution of the deaths being represented by the shape of the curve Mass. 1893–97. The diagramatic method is therefore more correct. The abnormal age distribution in 1906 results in making some of the figures in the last column of the table too large and some too small. In a general way, the figures for the earlier ages are too large and for the later ages too small, although the figures which are most too large are probably for ages 30 to 35. Consequently the greatest error in excess is for tuberculosis, which is possibly three-fourths of a year too large. No exact corrections are possible, and any systematic corrections, even inexact, would be very laborious. This would correspond to the elaborate actuarial calculations of Hayward in England and Glover in the United States. See Hayward "On the Construction of Life Tables and on Their Application, etc." Haydock and J. W. Glover, "A Study of Tuberculosis in the United States," Journal of Michigan State Medical Society, February, 1909.

	Preparatory period (ages 0-17½).		Working period of life (17½-60).		Period of decline (60 and beyond).		Total.	
	Years of life.	Per cent of total.	Years.	Per cent.	Years.	Per cent.	Years.	Per cent.
Mass. 1855	12.6	32	21.9	55	5.3	13	39.8	100
Mass. 1893-97	13.5	30	25.0	55	6.8	15	45.3	100
Possible I	15.4	26	31.8	55	10.9	19	58.1	100

These figures show that in 1855 the average person born lived only 12.6 years of the 17½ years in the period of preparation for life. In 1893–97 he lived 13.5 years. If modern hygiene were applied according to the ratios of the assigned preventability, the figure would then be 15.4 years actually lived out of the 17½. Of the working period of 42½ years (17½–60, the average man living under the mortality of 1855 had only about half, or 21.9 years; under the mortality of 1893–97 he had 25.0. and under the "Possible I" mortality he would have 31.8 years.

In percentage the years in the working period remain 55 per cent of the total life in all cases. This assumes that with the prolongation of life the limits of the working period remain 17½ and 60. Since the prolongation of life carries with it a postponement of the age of disability, it follows that the proportion of working life would actually increase.[a]

It will be seen in comparing the curves on the diagram that the change wrought in the character of the mortality curve by the new hygiene simply continues the change already in progress. The family resemblance between all four curves is striking.

SECTION 4.—*Fifteen years a safe minimum estimate of prolongation possible.*

The estimate of fifteen years as the possible prolongation of life is merely a minimum estimate. This will be seen from the following important considerations:

1. The estimate takes no account of future medical discoveries, which are now coming at such a rate that we have every reason to believe they will soon greatly increase the ratios of preventability. Cancer, for instance, has been put down with zero as its ratio of preventability, but the scientific world is intently seeking for methods of prevention and cure. Likewise "old age" has been assumed as unpreventable. Yet Metchnikoff maintains with reason that this is a malady which can be postponed.

2. The ratio of preventability of the above diseases takes little account of the cumulative influence of hygiene. Certain diseases late in life are now taken to be unpreventable or only slightly preventable on the assumption that people reach those ages in their present degree of more or less imperfect health. But on the assumption that personal hygiene had been practiced since birth, the vital resistance, which is always a deterrent of disease, would have been strengthened.

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[a] See Dr. Edward Jarvis, "Political Economy of Health," Fifth Annual Report, Mass. Board of Health, 1874, p. 338, ff.

Professor Sedgwick tells us that evidence will be published demonstrating "Hazen's theorem," that every life saved from typhoid by better water supply means two or three persons saved from deaths from other causes. Our table shows an estimate of at least 85 per cent as the preventability of typhoid, but the coincident preventability of other diseases which this prevention of typhoid would bring about finds no place in the table. The individual estimates given for these other diseases take no account of such indirect action. Similarly, as Metchnikoff has emphasized, venereal diseases, though they seldom cause death, do shorten life, the "terminal disease" being quite different. The same is true of malaria and hook-worm disease, which predispose to tuberculosis and other terminal diseases. But in the table the ratios of preventability of tuberculosis and other diseases were constructed quite irrespective of any effect from reducing venereal diseases, malaria, and other devitalizing diseases.

In the matter of personal hygiene the cumulative influence is still more indirect, and perhaps still more powerful. It is now often remarked by insurance men that the best risks are not necessarily the best physiques, but may be the valetudinarians who practice personal hygiene.

There is a vicious circle of disease and a beneficent circle of health. The so-called "cause of death" given in death certificates is only the terminal cause. It is often merely the "last straw" of a terrible load gradually accumulated through life.

Evidently, to exploit the resources of hygiene, we need to consider a thoroughgoing change in health ideals and a consequent revolution in the conditions and habits of living. What would then happen to human longevity we can only conjecture. The possible addition to the life span might, for aught we know, be several times the fifteen years in the table.

3. The figures for the possible prolongation of life take no account of the ultimate racial effects of the new health ideals. If once a nation becomes thoroughly alive to the importance of maintaining the stamina of its citizens, this will, as we have seen, affect marriages—by putting a premium on health as one of the desiderata in a prospective husband or wife. The longevity of succeeding generations would certainly be improved—how much, it would be useless to guess.

The foregoing considerations, added to the fact that the estimates of preventability were made conservatively, will show that the addition of fifteen years is really only a first step. If clean milk will prevent infantile diarrheal diseases, if clean water will prevent deaths from typhoid and at the same time—according to Hazen's theorem—prevent two or three times as many other deaths, and if clean air will prevent tuberculosis, then it is evident that mere cleanliness in respect to these necessities will suffice to lengthen life by most if not all of the above estimate. Fifteen years is merely the "ore in sight." If we will work for it, we may get an even richer prize.

> **Within the past few years the knowledge of the causes of disease has become so far advanced that it is a matter of practical certainty that by the unstinted application of known methods of invesigation and consequent controlling action, all epidemic disease could be abolished within a period so short as fifty years.**[a]

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[a] E. Ray Lankester, "The Kingdom of Man," New York (Holt), 1907, p. 36.

SECTION 5.—*Need of lengthening human life.*

If Metchnikoff's noble dream should be some day realized, the lengthening of human life would at once decrease the burden on the productive period. That period tends to remain 55 per cent of the total years lived, on the assumption that the working period remains 17½ to 60, but the upper limit tends to shift forward. In this way, both the absolute and relative length of the working period would be increased.

The further off the burden of old age is shifted, the easier it is for society or the individual to accumulate the wealth to provide for it. At present the burden of helpless old age is extremely serious, as those countries are beginning to realize which, like Denmark, Belgium, Germany, France, and recently England, have enacted laws to provide old-age pensions.

As life becomes more complex it requires a longer period of preparation. Preparation is education, and requires time. As the stock of knowledge increases, the period for acquiring it, or rather only enough of it to enable one to earn a livelihood, is constantly tending to increase. The age of leaving school and college is presumably growing greater.

It would be very much in keeping with the fitness of things if in this century biological science practically applied should shift the limit of the further end of the working period, the limit which we have assumed to be 60, to a later period of life. Human life would then be on a larger scale throughout. It would provide time for a longer and more thorough preparation and at the same time provide sufficient years of working life to repay this investment.

As Metchnikoff[a] well points out, one result of lengthening life will be a greater utilization of accumulated experience. We shall have less immaturity of judgment. The principle which leads to the choice for members of the judiciary of men of ripe years and knowledge will apply to every field of human activity, even those fields which are now preempted by young men because of the necessity of utilizing their vitality. It will lead to a sane and yet a vigorous conservatism. It will give to society a body of old yet hale men of experience, whose influence and worth can not be measured. As Metchnikoff has said:

> Old age, at present practically a useless burden on the community, will become a period of work valuable to the community. As the old man will no longer be subject to loss of memory or to intellectual weakness, he will be able to apply his great experience to the most complicated and the most delicate parts of the social life.[b]
>
> We may predict that when science occupies the preponderating place in human society that it ought to have, and when knowledge of hygiene is more advanced, human life will become much longer and the part of old people will become much more important than it is to-day.[c]

SECTION 6.—*The normal lifetime.*

What is the normal human lifetime?[d] Many estimates have been made, based on all sorts of reasoning, the figures extending from 75 to 200 years. Flourens's law, of doubtful value, that a mammal lives five times the length of its growing period, can not be applied generally. It is true, the horse full grown at 5 may live 25 years; sheep adult at less than 3 years may live 12; while elephants, which have an unusually tardy development, are reputed to have a lifetime of 2 centuries.

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[a] Prolongation of Life, p. 329.

[b] Nature of Man, p. 295.

[c] Metchnikoff: "Prolongation of Life," pp. 226–227.

[d] On the topic of human longevity, see Metchnikoff: "The Prolongation of Life," Pt. II, Chaps. I, II. Shaler: "The Individual," New York (Appleton), 1901, Chap. III. Lankester: "Comparative Longevity," London, 1870, pp. 88–119.

Haller, a distinguished Swiss physiologist of the eighteenth century, thought that man ought to live to [illegible]0 years; Buffon was of the opinion that when a man did not die from some accident or disease he would reach 90 or 100 years.[a]

In man the growth period is normally continued to some time after the twentieth year; its exact limit has not been ascertained, but from the statistics gathered by the Sanitary Commission during the civil war it seems most likely that it is not usually completed until after the thirtieth year.[b]

One method which has been suggested to ascertain the natural length of life is to suppose all diseases to be completely eliminated and those who now die of them to die of old age. The median age for death from old age is 83. Metchnikoff, however, shows the error of assuming present old age to be normal. We may conclude that the normal life exceeds 83.

There must needs be, of course, a limit to the possible prolongation of life. We find in recent times few authenticated cases of persons who have lived for a hundred years. As Young, former president of the British Actuarial Society, has shown in his interesting book[c] on centenarians, most cases of supposed centenarians are either cases of conscious or unconscious exaggeration or of error in records. For instance, the Countess of Desmond is said to have lived 130 years, owing to the confusion of two persons of the same name, one of whom lived to be 100 years old, while the other, her mother, died at 30, and their lives were combined in subsequent records. There are, however, some authenticated cases. Thus, the Norwegian Drakenberg was born in 1626 and lived until 1772, aged 146. "He was married when 111 years old, and as a widower of 130 proposed to marry again, although without success."[d]

At Portland, Oreg., Mrs. Mary L. Wood died recently at the age of 120 years and under circumstances which permitted the authentication of her case by the Oregon Historical Society. From these and from other cases which might be mentioned, we may conclude that if to-day, notwithstanding all existing chances of death, it is possible for some persons to live beyond 120, the chances in the future for a larger proportion of such persons will be materially improved. Whether this proportion could ever become the major part we have as yet no means of knowing. What is needed is study, and Metchnikoff is right in believing that the study is well worth while from every point of view.

APPENDIX TO CHAPTER XI.—*Method of computing possible prolongation of life.*

SECTION 1.—*"Expectation" at median ages as short cut to average expectations.*

The table given in Chapter XI is briefly described in the chapter itself. The following additional explanations are made in regard to the statistical method employed:

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[a] Metchnikoff, "Prolongation of Life," p. 84.

[b] Shaler, loc. cit., p. 61.

[c] T. E. Young: "Centenarians," London (C. & E. Layton), 1899.

[d] See article by Harald Westergaard, (British) Economic Journal, Vol. IX, 1899, p. 315.

The third column, giving the expectation of life which is lost or cut off by each particular cause of death, is estimated roughly by taking the expectation of life pertaining to the median age reached by those who die from the cause named. This expectation of life is taken from the Massachusetts Life Tables, 1893–1897.[a]

The method of using the median age is sufficiently exact in view of the inexact, or rather, safe, minimum estimates of preventability given in column five. A perfectly correct method would be much more laborious. Hayward's monograph on the effect on the duration of life of eliminating only one disease (tuberculosis) requires 190 pages of calculation. The true method consists in averaging arithmetically and weighting these averages according to the number dying at the various ages. Specimen computations show that the error involved by the short cut is not great.

Thus, for tuberculosis it is found that the average expectation of life lost by consumptives dying in 1906 was 32 years, whereas the expectation of life at the median age was 33 years. The former figure is a hundredfold more difficult to compute than the latter. Even the former is not strictly correct, since it applies to the deaths by ages as distributed in 1906, and not as distributed in a "stationary" population.

SECTION 2.—*Basis of estimates of preventability.*

The estimates of preventability given in column 5 need special explanation. In a few cases, these estimates are based on statistical experience.[b]

The great majority of them are based on clinical experience merely, without any exact statistics. They are thus in the nature of expert guesses. The experts in all cases are physicians. I have not entered any estimate of my own, unless item No. 36 might be so designated. This item is the residuum of deaths from unknown causes, or ill-defined causes, and is made up to a large extent of cases not properly reported in the death certificates. Inasmuch as the average preventability for all other causes in the table is over 42 per cent, it seemed safe to assign to deaths from these unknown causes a ratio of preventability of 30 per cent. But even if the preventability were entered as 0, the effect in reducing the result would be less than a year.

Those who gave to the construction of these estimates the benefit of their experience, observations, and reading were especially asked above all to be conservative. In order to avoid any possibility of exaggeration of their estimates in the table their average was taken, and then the estimate, as entered in the table, was taken either as that average or below it. In no case was the estimate entered as above the average given. When, as was true in a large proportion of cases, the different estimates agreed fairly well, the average was employed, or rather the nearest figure ending in 0, or 5 next below the average. If the individual estimates diverged widely, an estimate was used below the average, favoring the conservative estimators rather than the optimistic. Also in cases where only a few estimates were obtainable, the estimate as entered was put below the average of those given.

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[a] S. W. Abbott, M. D.: "The vital statistics of Massachusetts for 1897, from the thirtieth annual report of the state board of health of Massachusetts." The expectation is taken as the average of the expectations for males and females.

[b] In addition to the data in regard to special diseases discussed in the text, other pertinent material has been taken into account by those who made the estimates presented in the table. For instance, from smallpox in London in 1901–2 the mortality was 34.6 per cent among the unvaccinated, 20.9 per cent among those vaccinated after the disease was apparent, and 10.3 per cent where there was protective vaccination. In Gloucester in 1895–96 the mortality among the unvaccinated was 40.8 per cent and among the vaccinated 9.8 per cent. For children under 1 year the unvaccinated had a mortality of 72 per cent, while the vaccinated were not attacked. From cerebro-spinal meningitis the average mortality was 70 per cent (Holt); the mortality under serum treatment was 25 per cent (Flexner and Jobling). For typhoid fever, Koch and his assistants stamped out the disease in Trier by isolation of the infected persons and disinfection. (Osler, The Practice of Medicine, sixth edition.) This would probably be impracticable to such an extent in a city on account of the great expense involved and the difficulty of detecting the bacillus carriers. Other figures for typhoid fever are given in the text. For diphtheria in New York City in 1889–1891 we find the mortality was 37.3 per cent, while in 1902–1904 the mortality was 10.8 per cent. The board of health began to use antitoxin in 1895. These facts were furnished by Professor Blumer. Many data on preventability are given by John C. McVail in The Prevention of Infectious Diseases, New York (Macmillan), 1907. See especially pages 16–19. Doctor Stiles, of the Public Health and Marine-Hospital Service, is soon to publish figures showing the absolute preventability of hook-worm disease, a malady prevalent in the South, but not entering into the census tables. These tables do not cover the Southern States.

In estimating the percentage of preventability for all the ninety causes of death, 18 estimators contributed. The number of estimates of preventability for each cause averaged nearly eight for each cause of death. It will be seen, therefore, that the table represents in a conservative way medical opinion as to the preventability of disease. The physicians who contributed these estimates are: Dr. Joseph M. Flint, professor of surgery, Yale Medical School; Dr. George Blumer, professor of the theory and practice of Medicine, Yale Medical School; Dr. H. L. Swain, clinical professor, Yale Medical School; Dr. Oliver T. Osborne, professor of therapeutics, Yale Medical School; Dr. J. H. Townsend, secretary of Connecticut state board of health; Dr. F. W. Wright, health officer of New Haven; Dr. Norman E. Ditman, of Columbia University; Dr. Cressy L. Wilbur, Chief of Division of Vital Statistics, Bureau of the Census; Dr. L. O. Howard, Chief of Bureau of Entomology, Department of Agriculture; Dr. William C. Woodward, chief health officer of District of Columbia; Dr. Charles V. Chapin, city health officer, Providence, R. I.; Dr. Henry B. Baker, ex-secretary Michigan state board of health, ex-president American Public Health Association; Dr. J. H. Kellogg, superintendent of the Battle Creek Sanitarium; Dr. Charles H. Castle, of Cincinnati, Ohio; Dr. Harry M. Steele, of New Haven, Conn.; Dr. L. Emmett Holt, of New York; Dr. Edwin O. Jordan, of the Memorial Institute for Infectious Diseases, Chicago, Ill.; Dr. Prince A. Morrow, president of the American Society for Sanitary and Moral Prophylaxis.

SECTION 3.—*Meaning of "preventable."*

The meaning of the word "preventable" requires some explanation.

1. It is to be noted that column 5 gives the ratio of preventability for mortality and not for morbidity. It means ratio of preventable deaths to all deaths, not to all cases of illness.

2. Since the word "preventable" implies the hypothesis of different conditions from those which actually exist, it is necessary to specify what hypothetical conditions shall be implied in the term. Doubtless tuberculosis would be over 99 per cent preventable if we should conceive as our hypothetical conditions that every individual could live on the prairies of the West, out of doors, be provided with the best of food, most congenial of tasks, and free from overwork and worry. Needless to say, the figures in the table do not imply such Utopian conditions, nor do they imply new medical discoveries. One hundred per cent of every disease might be preventable if we conceived as our hypothesis that the means of prevention are known and applied. The hypothetical condition selected for the meaning of the term "preventable" is contained in the following definition: *A "ratio of preventability" is the fraction of all deaths which would be avoided if knowledge now existing among well-informed men in the medical profession were actually applied in a reasonable way and to a reasonable extent.* The term "reasonable" is of course elastic, and will be somewhat differently interpreted by different persons, but, as in law, where "reasonable care" is often used as a proviso, it is impossible to make any more specific condition.

3. Considerable confusion exists in the minds of many people in regard to the number of deaths which might be prevented, or, as it is popularly expressed, the number of lives which might be saved. Since death is ultimately inevitable for all, no life can be saved except temporarily. It will serve to avoid confusion if "preventable" is explained as "postponable." The question arises when deaths are postponed, How long are they postponed? The answer is, They are supposed to occur according to existing rates of mortality. Thus, those saved from croup (No. 12) at age 2 will later die as do others who are living at age 2, and will therefore have the expectation of life (54 years) pertaining to that age.

4. The above explanation will serve to meet an objection which otherwise would immediately occur to the reader. If diseases of early life are prevented, the result will necessarily be an increase of the diseases in later life. For instance, if all the causes of death could be abolished except old age, there

would be a great increase in the number of deaths from old age, which, instead of constituting the 2 per cent of all deaths, which it does at present, would constitute 100 per cent.

But the fact that all lives saved will add to the later mortality is fully, and more than fully, taken into account in our calculations. When we assume that certain lives now lost at a given age might be saved, we also assume that they would not be saved again (even from the same disease), but would die off according to the old rates of mortality at successive ages. Their new lease of life would simply be the old expectation of life. As a matter of fact, lives now lost could probably be saved, not only once, but several times.

We may here explain the paradox mentioned in the text—namely, that a preventability of 42.3 per cent of deaths under present conditions does not imply that the death rate would ultimately be reduced 42.3 per cent.

The death rate would ultimately depend on conditions of the distribution of ages and diseases entirely different from those now prevailing. This will be clear if we think what would happen if the preventability expressed in the table could be immediately applied. During the ensuing year it would be found that about 42 per cent of present deaths would not occur. A consequence of this, however, would be that the persons whose lives were prolonged would die at a later period, since no death is absolutely prevented, but only postponed. Even if 100 per cent of all deaths were prevented (postponed), but the postponement were for a very short time, the effect in reducing the death rate would be extremely small. On the other hand, if only 1 per cent of the preventable deaths were postponed for a sufficiently long time, the ultimate effect would be to reduce the death rate much more than 1 per cent. After the deaths which had been postponed had reentered, a new equilibrium would be established. Under these new conditions the ratio of the deaths to the population would not be 42.3 per cent lower than at present, but only about 25 per cent. At present the average duration of life, taken from the Massachusetts table for 1893–1897, is about 45 years. The ratio of preventability in the above table would increase this life by about fifteen years, making it 60 years. The ratio of 45 to 60, showing the increase in the life span, will be the inverse of the ratio 60 to 45 in a "stationary" population, which would show the resulting reduction in the death rate. This is a reduction of 25 per cent. Thus the preventability of 42.3 per cent of deaths under present conditions and in the manner indicated in the table involves a lengthening of life of 33⅓ per cent and a reduction of the death rate, after readjustment of deaths by ages, of about 25 per cent.

SECTION 4.—*Error from abnormal age distribution of deaths in 1906.*

The table as given is constructed for deaths occurring in the calendar year 1906. Its interpretation, however, is to be made on the basis of a survivorship table. In a stationary population the age distribution of deaths in any year would be the same as in a survivorship table; but since the United States has not a stationary population, this identity holds only approximately.

The discrepancy accounts for the difference of one and three-tenths years in the prolongation of life, as calculated in the table and by means of the diagram. The latter is the more correct, as it is based on a survivorship table, or—what amounts to the same thing—on such mortality as would exist in a stationary population. The only way in which this diagram can be vitiated by the slightly abnormal age distribution of deaths in the year 1906 is as this abnormal distribution affects the average ratios of preventability used in constructing the diagram. These ratios are based on column (5) of the résumé of the table. The four figures from the table are adjusted by graphic interpolation in the usual way, so as to form a continuously varying series of figures for successive years of life. These ratios are in each case an average of the individual ratios for particular diseases, contained in the same column (5) of the larger table. The "weights" are slightly vitiated by the fact that the age distribution of deaths in 1906 is not the normal distribution of a stationary population. It is only as the "weighting" is thus affected that the diagram can be vitiated through our being forced to use the figures for 1906 instead of those for an ideal stationary population, since such figures are unobtainable. The error from this source is infinitesimal, and we may depend on the results of the diagram, 12.8 to 14.9 years, as practically free from any appreciable error due to the use of short-cut methods.

SECTION 5.—*Ratios of preventability by ages derived from ratios of diseases.*

In regard to the résumé containing the average ratios of preventability holding true during different ages, it will be observed that they are obtained indirectly, by calculating from the individual ratios of preventability for different diseases given in the table itself. Although these diseases are not absolutely limited to the times within which their median falls, there is a fairly distinct line of demarcation between the groups, especially between children's diseases and those of middle life. The table shows no disease with a median age of incidence between 8 and 23 years, and the census table of deaths for 1906 shows that a very small percentage of the total deaths occur between ages 10 and 20. Even if the diseases considered for the four epochs of life given in the résumé did extend somewhat into the regions of the adjacent epochs, the effect would not change the result appreciably and would be as likely to change it in one direction as the other. The reason is that the items of the column in the résumé for "ratio of preventability" are obtained by dividing the figures in column 6 by those in column 4, each of these two being found by adding the individual figures in the table for each age group concerned. The extension of diseases of an age group outside of that group will apply equally to both terms of the ratio, those in the fourth and sixth columns, and will not substantially affect the quotient in the fifth column.

SECTION 6.—*Allowance for weakness of prolonged lives.*

The use in column 2 of the expectations of life derived from the Massachusetts 1893–1897 life table is equivalent to the assumption that if preventable deaths were prevented the lives thus saved would proceed to die off according to the mortality of Massachusetts, 1893–1897. This assumes that since 1893–1897 there has been no improvement in the expectation of life, and that the saved lives will not share in the improvement which the table itself shows forth. The reason that a later life table than for 1893–1897 was not used is that no later life table is available. If it were, it would show larger figures in column 2, and consequently a larger total result for the possible prolongation of life than fourteen years.

The reason the "expectation" in column 3 does not take account of the effect of the improvement in mortality resulting from the table is that this improvement can not be calculated until column 3 is filled, and we prefer to use as a first approximation a conservative figure in column 3, rather than to guess at more likely figures. The conservative assumption used seems also advisable, because of the fact that in the 42.3 per cent of persons in the life table who would be saved from death and given a new lease of life there would be suffered a greater mortality than that of the average persons that now pass that age in safety, for—on the principle of the survival of the fittest—it is intrinsically probable that those who now die at any age are weaker than those who do not.

How much allowance should be made for this factor of differential mortality it is impossible to say with certainty. But in another paper [a] I have dealt with the same question applied to tuberculosis. Taking the figures of Dr. Lawrason Brown, giving the mortality experience among the apparently cured cases of tuberculosis discharged from the Adirondack Cottage Sanitarium, and making certain allowances, it seems that if tuberculosis were prevented its present victims would have more than three-fourths of the expectation of life belonging to others. Let us assume that this ratio is equally conservative as applied to all other cases of prolongable life. Now, it so happens that the expectation of life at birth in the Massachusetts life table of 1893–1897 is almost exactly three-fourths of the expectation which our table and diagram shows would be possible if prevention were properly practiced. This would give 45 years as the expectation of life at birth for the saved lives, 61 for other lives, and 59 for all lives. Surely this seems sufficient allowance for the existence of any possible inferiority among the lives which would be saved.

SECTION 7.—*Diagram "Possible I," making this allowance, compared with "Possible II," omitting it.*

If no allowance for inferiority among saved lives were necessary, the results of the calculation given in the table would be only a first approximation and would need to be followed by successive and closer approximations. We can get much quicker results by means of the diagram and a planimeter.

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[a] "The cost of tuberculosis in the United States and its reduction," read before the International Congress on Tuberculosis, 1908.

If we apply the ratios of preventability for these four groups, we are able to construct the new survivorship table on the basis of Mr. Abbott's for 1893–1897. All that is necessary is to begin the new survivorship table at the same point that the old begins, and continue from that point and every other point throughout its course by the following procedure: Through the point draw a line downward and to the right for one year, at the same percentage slope as Abbott's table shows for that year. This line indicates what survivors there would be if their mortality were not affected at all by the ratio of preventability. The deaths during that year would be represented by the drop of the curve within the year. Next, taking the proper fraction of this drop, as indicated by the ratio of preventability, we pass vertically upward this amount from the end of the line, and from the new point so obtained proceed in like manner for each subsequent year. The result is a series of teeth the upper points of which are points on the required curve. Joining these points, we obtain the curve. This process explains the theory. This gives the table called "Possible I," and takes full account of the fact that the ratios of preventability continue to apply to saved life as much as to other life. The table "Possible I" represents the survivorship table, under the assumption that the lives saved once are given no further advantages, but follow thereafter the old law of mortality, that for 1893–1897.

SECTION 8.—*Reciprocal relation between longevity and mortality shown by diagram.*

We may take this opportunity to explain, for the benefit of the general reader, the reciprocal relations existing between the death rate in a stationary population and the average duration of life. Consider the diagram "Massachusetts, 1893–1897." It shows the life history of 100,000 persons born. Let us suppose a community unaffected by emigration or immigration, and in which there are 100,000 births each year. Let us suppose, further, that the 100,000 persons born each year die afterwards according to the law of mortality represented by the curve "Massachusetts, 1893–1897." Evidently in such a community there will not only be 100,000 births, but there will be 100,000 deaths each year, and the population will be stationary. It will also be true that the same diagram can be taken to represent the age distribution of this stationary population. Thus, those living at age 10 will be the survivors of the 100,000 born ten years ago, and the number of such survivors is the ordinate of the curve at 10 years. Thus, every ordinate of the curve represents not only the survivors to a certain age out of 100,000 births, but also represents the number in the population at that age. The area of the curve therefore represents total population (when regarded as made up of vertical sections). It likewise represents the total number of years lived by 100,000 persons (when regarded as made up of horizontal sections). Now, the death rate is the ratio of deaths to population—i. e., the ratio of 100,000 to the area of the curve. The average duration of life is the total years lived by 100,000 persons divided by 100,000—that is, it is the area of the curve divided by 100,000. These are clearly reciprocals.

CHAPTER XII.—*The money value of increased vitality.*

SECTION 1.—*Money appraisal of preventable wastes.*

Estimates of the money value of preventable wastes depend on the valuation of *human life*, of which several appraisals have been attempted.

Prof. J. S. Nicholson estimated that in Great Britain human labor capitalized was worth five times all other capital.[a]

Engel computed that each child costs 100 marks at birth, 110 marks the first year, 120 the second, and so on. At 20 he will have cost 2,310 marks, or $560. But one-half die before 20. Hence each person who reaches the age of 20 actually costs society much more than $560; possibly as high as $1,000, if Engel's estimates are correct. Professor Mayo-Smith estimated that men and women between the ages of 15 and 45 averaged $1,000 in value.[a] As to the value of immigrants to this country, he says: "Every immigrant must represent labor value with at least the value of a slave. It is figured that each immigrant is worth $875."[b]

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[a] See "The Living Capital of the United Kingdom" (British) Economic Journal, 1891.

The best method of estimating the economic value of life and its increased duration is by the capitalization of earning power. Dr. William Farr, of England, has estimated that a baby born to an English agricultural laborer is worth in capitalized earning power about £5, or $25. This is the discounted value of its future earnings estimated on its probable life less the discounted value of the cost of rearing it during the period of dependence and of maintaining it when helpless through old age. In the same way he estimates the value of a life at other ages—10 years, 20 years, 50 years, etc.[c]

In lieu of any estimates for the United States we may take Farr's figures for agricultural laborers as representing, roughly, the relative worth of a man or woman in the United States. To obtain the absolute figures, therefore, we need simply to multiply these of Farr by a constant factor representing the ratio between the average earnings in the United States and the earnings which Farr uses as the yearly income of an agricultural laborer.

We take, in the absence of any good statistics, $700 per annum as a guess, but a safe minimum[d] for the average earnings of workers of all grades, from day laborers to railroad presidents. This assumes that all of the working years are actually employed in work. But since about one-fourth of the persons of working age are not workers, but are supported (for the most part) by earnings of capital, the average should be cut down to three-fourths of this figure, or $525.

Substituting this figure for the £31 in Farr's table, we can reconstruct it to represent the minimum worth of the average American life at different ages. The following figures are taken from the table thus computed:

Age.	Net worth of a person, in dollars.	Age.	Net worth of a person, in dollars.
0	90	30	4,100
5	950	50	2,900
10	2,000	80	−700
20	4,000		

From the table from which these figures are taken it is possible to base minimum estimates for (1) the average economic value of the inhabitants of the United States by using the census figures for age distribution of population; this calculated average is $2,900; (2) the average economic value of the lives now sacrificed by preventable deaths, using the age distribution of deaths, and the percentages of preventability; this calculated average is $1,700.

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[a] Mayo-Smith, Statistics and Sociology, p. 177.

[b] Mayo-Smith, Emigration and Immigration.

[c] See Farr, "Vital Statistics," p. 536.

[d] See Fisher "Cost of tuberculosis," read before the International Congress on Tuberculosis, Washington, 1908. This is the estimated minimum used in my paper on the "Cost of tuberculosis." The calculations are based on $1 a day as the ordinary minimum earnings of unskilled labor, and assume a distribution of a number of earners of high amounts according to the scale of distribution which Professor Pareto finds fairly uniform in form, although not in amount in various countries. The late honorable Carroll D. Wright, whose opinion is worth more, probably, than that of any other man in the United States, stated that he would not regard $1,000 as excessive. The figure is intended to include the earnings of women (including housewives as earners).

The first figure shows that what might be called the vital assets of the United States for the population of over 85,500,000, as estimated by the census of 1907, amount in value to 85,500,000×$2,900, or $250,000,000,000, which, though a minimum estimate, greatly exceeds the value of all other wealth;[a] the second figure enables us to estimate the needless waste of our vital assets.

If we take the estimate of Professor Willcox of the death rate in the United States, as at least 18 per 1,000 for the 85,500,000 persons estimated by the census as the population of the United States in 1907, we have 1,500,000 as the number of deaths in the United States per annum. Of these 1,500,000 deaths, 42 per cent, or 630,000, are annually preventable or postponable. Since each postponement would save on the average $1,700, the national annual unnecessary loss of capitalized net earnings is 630,000×$1,700, or $1,070,000,000, or about $1,000,000,000.

We saw in Chapter III that, with our present population, there are always about 3,000,000 persons in the United States on the sick list. For the most part these persons are older than the average. Farr gives a table[b] showing that morbidity increases with age in geometric progression. By means of his table we may calculate on the same basis as the previous calculations—that of the 3,000,000 sick, very close to a third, or 1,000,000 persons, are in the working period of life. Assuming that average earnings in the working period are $700, and that only three-fourths of the one million potential workers would be occupied, we find over $500,000,000 as the minimum loss of earnings.

The cost of medical attendance, medicine, nursing, etc., is conjectured by Doctor Biggs in New York to average for the consumptive poor at least $1.50 per day of illness. The cost per day of other illnesses than tuberculosis is presumably greater, and also the cost per day for other classes is higher than for the poor. Applying this to the 3,000,000 years of illness annually experienced, we should have $1,500,000,000 in all as the minimum annual cost of this kind.

The statistics of the Commissioner of Labor[c] show that the average expenditure for illness and death amount to $27 per annum. This is for workingmen's families only. But even this figure, if applied to the 17,000,000 families of the United States, would make the total bill for caring for illness and death $460,000,000. The true cost may well be more than twice this sum. Certainly this estimate is more than safe and is only one-third of the sum obtained by using Doctor Biggs's estimate.

The sum of the costs of illness, including loss of wages and cost of care, is thus $460,000,000+$500,000,000, or $960,000,000.

The above estimate is a general one for all illness. It would be possible to offer figures for the particular losses from particular diseases. Thus, from tuberculosis, the gross loss of earnings by illness and of potential earnings cut off by death, together with the expenses of illness, etc., amount to over $1,000,000,000 per annum.[a]

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[a] Mr. Le Grand Powers, of the Bureau of the Census, Washington, estimates that the total wealth in America (exclusive of human beings) amounts to $107,000,000,000.

[b] Vital Statistics, p. 510.

[c] Eighteenth Annual Report, 1903, p. 509.

Of the sum mentioned, the loss to the consumptives themselves amounts to over $660,000,000, leaving $440,000,000 as the loss to other members of the community. At least three-fourths of these costs are preventable. Dr. George M. Kober thinks it is conservative to say that the annual cost of typhoid in the United States is $350,000,000[b] and Dr. L. O. Howard believes that malaria alone costs the country $100,000,000 annually, and the insect diseases generally $200,000,000.[c] He points out that one great item of loss is the reduced value of real estate in malarial regions. By drainage and destruction of mosquitoes most of this waste could be saved. The cost of the care of the insane and feeble-minded is estimated by Charles L. Dana at $85,000,000 annually.[d] What fraction of these costs is preventable it is difficult to say. The economic loss due to alcohol has been variously estimated.[e] Of the billion dollars or more found to represent the cost of illness, by far the major part is certainly avoidable. This is the belief of the best observers, such as Doctor Gulick, Doctor Kellogg, Mrs. Richards, Doctor Anderson, and others. Unfortunately there are no exact statistics of preventability. We feel safe, however, in concluding that at least half a billion could be saved from the present cost of illness. This, added to the loss by preventable deaths of potential earnings of a billion, gives at least a billion and a half of preventable waste. This does not include the losses from inefficient work due to drunkenness or other vicious habits; nor does it include the cost of "undue fatigue," which we have some reason to believe exceeds in its effect on efficiency the loss from illness. But it would not be possible to state this loss in any definite or convincing figures.

The actual economic saving annually possible in this country by preventing needless deaths, needless illness (serious and minor), and needless fatigue, is certainly far greater than one and a half billions, and may be three or more times as great.

Dr. George M. Gould estimated that sickness and death in the United States cost $3,000,000,000 annually, of which at least a third is regarded as preventable.[f]

> The trouble is the public does not believe in this waste from being "just poorly," and "so as to be about." It has no conception of the difference between working with a clear brain and steady hand and with a dull and nerveless tool. They must be convinced somehow.[g]

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[a] See Irving Fisher: "Cost of Tuberculosis in the United States, and its Reduction."

[b] See his "Conservation of life and health by improved water supply," read before the White House Conference of Governors, 1908.

[c] Report to Conservation Commission on "Economic loss to the people of the United States through insects that carry disease."

[d] See "Psychiatry in its relation to other sciences," by Charles L. Dana, before the section on psychiatry at the International Congress of Arts and Sciences, St. Louis, September, 1904.

[e] "Economic aspects of the liquor problem." An investigation made for the Committee of Fifty, under the direction of Henry W. Farnam, secretary of the economic subcommittee, 1899, 327 pages.

[f] "Disease and Sin," American Medical Journal, August 31 and September 7, 1901.

[g] Letter from Ellen H. Richards.

SECTION 2.—*The cost of conservation.*

It costs no more to "raise" a man capable of living for 80 years than it does to "grow" one who has not the capacity of living to be 40 years old.[a]

We have seen how much potential value of life is now allowed to be wasted which could be prevented. But the question remains, What would it cost to conserve it? It is, of course, not possible to answer this question definitely and fully. The best we can do is to point out specific instances of the health returns which follow on investments in the improvement of vital conditions.

The following examples will show the returns which may be expected from well-planned expenditures on behalf of public health:

> The city of Pittsburg is just installing a great municipal filter plant for the purification of its principal water supply, at an expense of upward of $7,000,000. It is reasonable to estimate that in a year or two this should effect a saving of 100 deaths a year from typhoid fever, for the number of typhoid-fever deaths of late years has been 400 or more yearly. Valuing these lives at $5,000 each, as is customary, the saving effected by the purification works should be half a million dollars' worth of human life annually, making the building of the filter a sound and profitable economic as well as humanitarian measure. But if, as Mr. MacNutt and I have shown, Hazen's theorem is true, then for every 100 deaths saved from typhoid fever at least 200 will be saved from other causes, which means at least $1,000,000 more saved to the city of Pittsburg annually of its present waste of human life.[b]
>
> England reckons that the lives saved through the lowered death rate, from what it was between 1866 and 1875 to what it became in the period reaching from 1880 to 1889, amounted to 858,804. This represents on the English basis of the per capita valuation of each life ($770) a social capital of $650,000,000 saved. In ten years England has more than regained the sum spent in fifteen years for sanitary improvements, though the average annual expenditure has been $42,000,000.[c]
>
> The achievement of Huddersfield, England, is especially noteworthy. The average number of deaths of infants for ten years had been 310. By a systematic education of mothers the number was in 1907 reduced to 212. The cost of saving these 98 lives was about $2,000.[d]

A saving of infant life is recorded by Doctor Chapin in Providence:

> We attempted for two years to distribute clean milk to the babies of the poor, but this year we decided that the money could better be spent on trained nurses. Thus far we have expended about $900 for this purpose. Two hundred and thirty-five sick children, of whom very many were very sick, have been cared for. Of these only 20 have died. From a study of our statistics I should judge that the reduction in infant mortality effected by the nurses was at least 25 deaths, and it may be that as many as 40 lives were saved.[e]

At the funeral of Maj. Walter Reed, the man who did so much to prove the correctness of Doctor Finley's discovery that the mosquito is the carrying agent for the yellow-fever germ, Gen. Leonard Wood declared that this discovery is saving more lives annually than were lost in the Cuban war, and that it is saving the commercial interests of the world a greater financial loss each year than the cost of the entire Cuban war.[a]

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[a] T. S. Lambert: "Sources of Longevity," New York, 1869, p. 6.

[b] W. T. Sedgwick: "The call to public health," Science, 1908, p. 198.

Since the foregoing was written, there has appeared in "Charities," February 6, 1909, "Thirty Five Years of Typhoid" by Frank E. Wing, in which it is shown that there were in 1907, in Pittsburg, 4,921 cases of typhoid, of which 622 died; and that the cost per patient, irrespective of the lives lost, was $128, making the cost for the city $694,000. Reckoning $4,000 as the value of each life lost, the total annual money cost from typhoid in Pittsburg is over $3,000,000, and, according to Hazen's theorem, already mentioned, this is probably not one-half nor even one-third of the total.

[c] Ditman, loc. cit., p. 4. Taken from M. G. Dana: "Results of municipal sanitation," Annals of Hygiene, 1896, Vol. II, p. 391.

[d] Letter from Dr. Charles V. Chapin.

[e] Ibid.

As to what the stamping out of yellow fever means, in money terms, the following is significant:

> It has been estimated that the yellow fever epidemic of 1878 invaded 132 towns, caused a mortality of 15,954 persons, and that the pecuniary loss to the country was not less than $100,000,000 in gold.[b]

The economic loss to Philadelphia, caused by the smallpox epidemic of 1871–72 has been estimated by Doctor Lee at $22,000,000. This includes loss to travel and traffic on railroads, loss to hotel keepers, merchants, and manufacturers, cost of care of sick, loss of time, and the expense of burial. A vaccine bureau with physicians, a disinfecting station, and the inauguration of a campaign of education capable of forestalling the whole epidemic would have cost $700,000.[c]

It is reported that San Francisco plans an investment of $30,000,000 in stone and concrete quays to prevent rodents from infecting the city, and this is regarded by experts as worth while many times over.

In respect to hook-worm disease, rating the earning per diem of the southern farm laborer at 75 cents, 28 observers report that average laborers infected with hook-worms earn 40 cents per diem. Ten observers having cotton-mill practice report unanimously that the disease is very prevalent among cotton-mill laborers, and rating the average mill laborers at $1.50 per diem, they consider 75 cents as a fair rating for hook-worm bearing laborers.[d]

> It would be difficult to even roughly estimate the cost of this disease to the South, but from what we know of it in this State I would say that it costs South Carolina not less than $30,000,000 per year, and this inability to perform regular and efficient labor is the smallest part of the cost.[e]

It has been figured that the hook-worm disease of the South could be wiped out within a generation[f] through the expenditure of from one to two millions of dollars by federal and state agencies. It costs about 15 to 75 cents (wholesale) for drugs to cure a case of hook worms. In three months the quantity of red corpuscles in the blood can easily be increased 10 to 50 per cent, according to the severity of the case, and the[g] absenteeism of the victims could easily be reduced 25 per cent.

> Another noteworthy result of well-directed sanitary effort is the reduction of hook-worm disease in Porto Rico. As you are doubtless aware, this disease causes a tremendous lowering of the physical efficiency of the people of that island. As you may see by the report of the special commission for 1906 and 1907 made to Governor Post, 89,000 people were treated, and for the most part cured, for 54 cents each.[h]

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[a] Ditman, loc. cit., p. 12.

[b] Walter Wyman, M. D., "Quarantine and Commerce," address before Cincinnati Commercial Club, October 15, 1898, p. 8.

[c] Ditman, loc. cit., pp. 8–10, from Bissell, A Manual of Hygiene.

[d] Letter from Dr. W. J. Burdell.

[e] William Weston, "Uncinariasis," South Carolina Medical Association, 1908, p. 8.

[f] Dr. Charles W. Stiles, of the United States Public Health and Marine-Hospital Service, who has studied the hook-worm disease more thoroughly than any one in the country.

[g] Letter from Doctor Stiles.

[h] Letter from Charles V. Chapin, 1908.

Medical inspection in our schools also returns large dividends on small investments.

> Using these data as a basis, we have the annual expenditure for medical inspection of $345,135 in those cities from which we have succeeded in obtaining data. It seems probable, although this is frankly a guess, that the total annual expenditure for medical inspection of schools in the United States at the present time is perhaps $500,000.[a]
>
> The money saved by enabling thousands of children to do one year's work in one year, instead of in two or three years, would greatly exceed the total expense of examining all school children in all boroughs.[b]

Doctor Jessen has shown that the cost of a school dental clinic in Germany is only one mark per year per child.[c] The cost saved must be very many times this sum. Dr. Herbert L. Wheeler, of New York, estimates that the Children's Aid Dental Clinic in New York cost $342 for the last fiscal year (35 cents per operation and 70 cents per child treated). He reckons that the neglect of these slight repairs would later have cost far more in dentistry, as well as over $2,000 worth of lost time. These losses are of course of minor importance compared with the pain, inconvenience, and secondary effects on health and efficiency which are inevitably associated with bad teeth.

Mr. Edwin Chadwick, who was once secretary of the English National Board of Health, stated that a sanitary "engineer ought to contract for the reduction of the sickness and death rate, in such a city as Glasgow, by at least one-third, for a penny a head of the entire population."[d]

> It is necessary, if we are to do our utmost, to spend a thousand pounds of public money on this task where we now spend one pound. It would be reasonable and wise to expend ten million pounds a year of our revenues on the investigation and attempt to destroy disease. Actually what is so spent is a mere nothing, a few thousands a year. Meanwhile our people are dying by thousands of preventable disease.[e]

Mr. Hiram J. Messenger, actuary of the Travelers Insurance Company, of Hartford, has constructed and sent me a table showing that life insurance companies could probably make money now by taking a hand in the public-health movement, with the purely commercial object of reducing their death losses. He says:

> This table shows that if the companies were to expend $200,000 a year for this purpose and as a result should decrease their losses by the almost insignificant amount of twelve one-hundredths of 1 per cent, they would save enough to cover the expense. If such a plan as this were placed on a purely scientific basis and carried out by good business methods and all the companies pulled together for the common good, I should expect a decrease in death claims of more than 1 per cent. And a decrease in death claims of 1 per cent would mean that the companies would save more than eight times as much as they expended or would make a net saving of more than seven times the expense—which would be about a million and a half dollars a year.

The examples given show tangible returns on the investment of several thousand per cent as a rule. While it would be impossible to state in general terms how rich a return lies ready for public or private investments in good health, the foregoing examples and numerous others show that the rate of this return is quite beyond the dreams of avarice. Were it possible for the public to realize this fact, motives both of economy and of humanity would dictate immediate and generous expenditure of public moneys for improving the air we breathe, the water we drink, and the food we eat, as well as for eliminating the dangers to life and limb which now surround us.

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[a] Letter from Dr. Luther H. Gulick.

[b] Sixty-third Annual Report of the Association for Improving the Condition of the Poor, New York, 1906.

[c] See "Jahresbericht der Städtischen Schulzahnklinik in Strassburg," in Odontologische Blätter 12, No. 15–16, 1907.

[d] Transactions of the British Social Science Association, 1866, p. 580. Quoted by Dr. Edward Jarvis, Political Economy of Health, Fifth Report, Mass. Board of Health, 1874, p. 367.

[e] E. Ray Lankester, "The Kingdom of Man," New York (Holt), 1907, p. 148.

CHAPTER XIII.—*The general value of increased vitality.*

SECTION 1.—*Disease, poverty, and crime.*

In the preceding chapter we have attempted to estimate in money the preventable wastes from disease and death. Although the figures for national losses strike the popular imagination, they have little significance; in fact, money estimates in this field, even when made on the per capita basis, are of little value except as emphasizing the overwhelming importance of human vitality compared with those interests which are usually measured in money. It is impossible in any true sense to measure human life in terms of dollars and cents.[a] The measure of life may perhaps be found in happiness, or the satisfactions enjoyed between birth and death, less the dissatisfactions. Is life worth living? has been a much asked question, especially since Mr. Mallock wrote a book with that title. The witticism sometimes given in answer, "That depends upon the liver," is true in both of its two meanings. A life of happiness is always worth living, and a life of usefulness, which brings happiness to others, is doubly worth living.

It is hardly necessary to recount all the conditions which tend to produce happiness. No one would question that the most fundamental condition of all is health, in spite of exceptional cases in which unhealthy people are found happy, and healthy people unhappy. It would be impossible to express in exact terms the extent to which improved health could increase human happiness; but every observer of human misery among the poor reports that disease plays the leading rôle. Students of criminology and vice agree that these are chiefly the result of morbid conditions and habits. Health reform brings in its train great and lasting reductions in poverty, criminality, and vice.

We began this report by showing the relation between the conservation of health and the conservation of wealth. The broadest view of this relation is, as Emerson has said, that "Health is the first wealth," and as such it is treated by many economists.[b]

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[a] Even as a measure of what economists call "utility," a money estimate is misleading, for the reason that the "marginal utility" of money varies with different persons. For instance, a week's wages of $10 lost to a poor wage-earner is in such an estimate counted on a par with an expenditure of $10 by a wealthy invalid for a dainty morsel of food, although the loss in "utility" to the former is vastly greater than that to the latter.

[b] Among those who have included health in the category of wealth are Davenant, Petty, Canard, Say, McCullough, Roscher, Wittstein, Walras, Engel, Weiss, Dargun, Ofner, Nicholson, and Pareto. See Irving Fisher: "The Nature of Capital and Income," New York (Macmillan), 1906, p. 5.

Without enlarging or insisting upon this concept, it is obvious that by the conservation of health we may ultimately save billions of dollars of wasted values, and that this conservation is intimately related to conservation of all other kinds.[a]

We have already seen the vicious circle set up between poverty and disease, each of which tends to produce the other. Metchnikoff[b] contends that health and morality are correlative, if not interchangeable, terms. A similar idea has been elaborated statistically by Dr. George M. Gould.[c] The subject is worth much further study. National efficiency is crippled by any one or all of the parts of the vicious circle—disease, poverty, vice, vagabondage, crime. It would be interesting to study the tramp problem, which represents an enormous waste of labor power, in relation to all these phenomena.

SECTION 2.—*Conservation of natural resources.*

It is also true that health begets wealth, and vice versa. Whatever diminishes poverty or increases the physical means of welfare has the improvement of health as one of its first and most evident effects. Therefore an important method of maintaining vital efficiency is to conserve our natural resources—our land, our raw materials, our forests, and our water. Only in this way can we obtain food, clothing, shelter, and the other means of maintaining life. Conversely, the conservation of health will tend in several ways to the conservation of wealth. First of all, the more vigorous and long-lived the race, the better utilization can it make of its natural resources. The labor power of such a race is greater, more intense, more intelligent, and more inventive.

The development of our natural resources in the future will be more dependent on technical invention[d] than upon the mere abundance of materials.

Just as in warfare it is not so much the gun as the man behind the gun that makes for success, so in industry, as Doctor Shadwell[e] has shown, skill, knowledge, and inventiveness are the chief factors in determining commercial success and supremacy. The backward nations, like China, are characterized by lack of modern inventions. The nations which are industrially most advanced have the railway, the steamship, the power loom, metal working, and innumerable arts and crafts. The change of Japan from a backward to a forward nation is at bottom the introduction of inventions. If conservation prevents lessened fertility, invention makes two blades of grass grow where one grew before.

Future industrial competition will be increasingly a contest of invention. The world rivalry to develop the best system of wireless telegraphy or the best airships is but one example. The future will see the greatest strides taken by the nation which is the most inventive. Now, the primary condition of invention is vitality, a clear brain in a normal body. It is no accident that Edison is a health culturist, or that Krupp, Westinghouse, and other pioneers in industrial development have been men of vigor of mind and body.

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[a] See Edward Devine, "Efficiency and Relief," New York (Macmillan), 1906.

[b] Prolongation of Life, p. 318.

[c] "Disease and sin," American Medical Journal, Aug. 31 and Sept. 7, 1901.

[d] Since the above was written, President Charles S. Howe, of Cleveland, has presented this point in detail. See "The function of the engineer in the conservation of the natural resources of the country," Science, Oct. 23, 1908.

[e] Arthur Shadwell in his admirable "Industrial Efficiency" (2 vols.). London (Longmans), 1906.

Finally, the conservation of health will promote the conservation of other resources by keeping and strengthening the faculty of foresight. One cause of poverty in the individual and the nation is lack of forethought.[a]

One of the first symptoms of racial degeneracy is decay of foresight. Normal, healthy men care for and provide for their descendants. A normal, healthy race of men, and such alone, will enact the laws or develop the public sentiment needed to conserve natural resources for generations yet unborn. When in Rome foresight was lost, care for future generations practically ceased. Physical degeneracy brought with it moral and intellectual degeneracy. Instead of conserving their resources the spendthrift Romans, from the emperor down, began to feed on their colonies and to eat up their capital. Instead of building new structures they used their old coliseum as a quarry and a metal mine.[b]

The problem of the conservation of our natural resources is therefore not a series of independent problems, but a coherent all-embracing whole. If our nation cares to make any provision for its grandchildren and its grandchildren's grandchildren, this provision must include conservation in all its branches—but above all, the conservation of the racial stock itself.

CHAPTER XIV.—*Things which need to be done.*

SECTION 1.—*Enumeration of principal measures.*

In order that American vitality may reach its maximum development, many things need to be done. Among them are the following:

1. The National Government, the States, and the municipalities should steadfastly devote their energies and resources to the protection of the people from disease. Such protection is quite as properly a governmental function as is protection from foreign invasion, from criminals, or from fire. It is both bad policy and bad economy to leave this work mainly to the weak and spasmodic efforts of charity, or to the philanthropy of physicians.

2. The National Government should exercise at least three public health functions: First, investigation; second, the dissemination of information; third, administration.

It should remove the reproach that more pains are now taken to protect the health of farm cattle than of human beings. It should provide more and greater laboratories for research in preventive medicine and public hygiene. Provision should also be made for better and more universal vital statistics, without which it is impossible to know the exact conditions in an epidemic, or, in general, the sanitary or insanitary conditions in any part of the country.

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[a] See Irving Fisher: "The Rate of Interest," New York (Macmillan), 1907.

[b] See John Rae: "Sociological Theory of Capital," edited by Prof. C. W. Mixter, New York (Macmillan), 1905.

It should aim, as should state and municipal legislation, to procure adequate registration of births, statistics of which are at present lacking throughout the United States.

The National Government should prevent transportation of disease from State to State in the same way as it now provides for foreign quarantine and the protection of the nation from the importation of disease by foreign immigrants. It should provide for the protection of the passenger in interstate railway travel from infection by his fellow-passengers and from insanitary conditions in sleeping cars, etc.

It should enact suitable legislation providing against pollution of interstate streams.

It should provide for the dissemination of information in regard to the prevention of tuberculosis and other diseases, the dangers of impure air, impure foods, impure milk, imperfect sanitation, ventilation, etc. Just as now the Department of Agriculture supplies specific information to the farmer in respect to raising crops or live stock, so should one of the departments, devoted principally to health and education, be able to provide every health officer, school-teacher, employer, physician, and private family with specific information in regard to public, domestic, and personal hygiene.

It should provide for making the national capital into a model sanitary city, free from insanitary tenements and workshops, air pollution, water pollution, food pollution, etc., with a rate of death and a rate of illness among infants and among the population generally so low and so free from epidemics of typhoid or other diseases as will arouse the attention of the entire country and the world.

There should be a constant adaptation of the pure-food laws to changing conditions. Meat inspection and other inspection should be so arranged as to protect not only foreigners, but our own citizens. The existing health agencies of the Government should be concentrated in one department, better coordinated, and given more powers and appropriations.

3. State boards of health and state legislation should provide for the regulation of labor of women, should make physiological conditions for women's work and prevent their employment before and after childbirth; should regulate the age at which children shall be employed, make reasonable regulations in regard to hours of labor and against the dangers in hazardous trades, and especially against the particular dangers of dust and poisonous chemicals; should make regulations for sanitation and provide inspection of factories, schools, asylums, prisons, and other public institutions. Where municipalities have not the powers to enact the legislation above mentioned with reference to local conditions, the necessary legislation or authority should be provided by the State. Or where by reason of the small size of the town no efficient local action is possible, the State should exercise the necessary functions. It should in such cases advise and supervise local boards of health. It should have an engineering department and advise regarding the construction of sewers and water supplies. Pollution of such supplies, unless entirely local, should be prevented by the State, which should be equipped with laboratories for the analysis of water, milk, and other foods. Suitable legislation should be passed regulating the sale of drugs, especially preparations

containing cocaine, opium, or alcohol. Legislation—not too far in advance of public sentiment needed to enforce it—should be passed regulating the sale of alcoholic beverages. State registration of births, deaths, and cases of illness should be much more general and efficient than at present.

4. Municipal boards of health need to have more powers and greater appropriations; less political interference and better trained health officers; more support in public opinion. Their ordinances in regard to expectoration, notification of infectious disease, etc., should be better enforced by the police departments.

More legislation should be advocated, passed, and enforced to the end that streets may be kept clean, garbage properly removed, sewage properly disposed of, air pollution of all kinds prevented, whether by smoke, street dust, noxious gases, or any other source. Noises also should be lessened.

Municipalities need also to take measures to prevent infection being carried by flies, mosquitoes, other insects and vermin, and by prostitution. They need to guard with greater care the water supply, and in many cases to filter it; they should make standards for milk purity and enforce them; they should also regularly inspect other foods exposed for sale; provide for sanitary inspection of local slaughterhouses, dairies, shops, lodging and boarding houses, and other establishments within the power of the particular municipality; they should make and enforce stricter building laws, especially as relating to tenements, to the end that dark-room tenements may be eliminated and all tenements be provided with certain minimum standard requirements as to light, air, and sanitary arrangements.

5. School children should be medically inspected and school hygiene universally practiced. This involves better protection against school epidemics, better ventilation, light, and cleanliness of the schoolroom, the discovery and correction of adenoids, eye strain, and nervous strain generally, and the provision for playgrounds. Sound scientific hygiene should be taught in all schools, public, private, normal, and technical, as also in colleges and universities.

6. The curricula of medical schools should be rearranged with a greater emphasis on prevention and on the training of health officers. Sanatoria and hospitals, dispensaries, district nursing, tuberculosis classes, and other semipublic institutions should be increased in number and improved in quality. The medical profession, keeping pace with these changes, should be the chief means of conveying their benefits to the public. Universities and research institutions need to take up the study of hygiene in all its branches. Now that the diseases of childhood are receiving attention, the next step should be to study the diseases of middle life. These are diseases, to a large extent, of nutrition and circulation, and consequently these subjects should receive special attention. Intelligent action must rest on knowledge, and knowledge of preventing disease is as yet extremely imperfect.

7. In industrial and commercial establishments employers may greatly aid the health movement, and in many cases make their philanthropy self-supporting by providing social secretaries, lunch and rest rooms, physiological (generally shorter) hours of work, provision for innocent amusements, seats for women, etc.

Life insurance companies could properly and with much profit club together to instruct their risks in self-care and secure general legislation and enforcement of legislation in behalf of public health.

8. The present striking change in personal habits of living should be carried out to its logical conclusion until the health ideals and the ideals of athletic training shall become universal. This change involves a quiet revolution in habits of living, a more intelligent utilization of one's environment, especially in regard to the condition of the air in our houses, the character of the clothes we wear, of the site and architecture of the dwelling with respect to sunlight, soil, ventilation, and sanitation, the character of food, its cooking, the use of alcohol, tobacco, and drugs, and last, but not least, sex hygiene in all its bearings.

9. The fight against disease will aid in the fight against pauperism and crime. It is also true that any measures which tend to eliminate poverty, vice, and crime will tend to improve sanitary conditions.

10. Finally, eugenics, or hygiene for future generations, should be studied and gradually put in practice. This involves the prohibition of flagrant cases of marriages of the unfit, such as syphilitics, the insane, feeble-minded, epileptics, paupers, or criminals, etc. The example of Indiana in this regard should be considered and followed by other States, as also in regard to the unsexing of rapists, criminals, idiots, and degenerates generally. A public opinion should be aroused which will not only encourage healthy and discountenance degenerate marriages, but will become so embedded in the minds of the rising generation as will unconsciously, but powerfully, affect their marriage choices.

ECONOMIC LOSS TO THE PEOPLE THROUGH INSECTS THAT CARRY DISEASE.

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It has been definitely proven and is now generally accepted that malaria in its different forms is disseminated among individuals of the human species by mosquitoes of the genus *Anopheles*, and that the malarial organism gains entrance to the human system, so far as known, only by the bite of mosquitoes of this genus. It has been proven with equal definiteness, and has also become generally accepted, that yellow fever is disseminated by the bite of a mosquito known as *Stegomyia calopus* (possibly by the bites of other mosquitoes of the same genus), and so far as has been discovered this disease is disseminated only in this way. Further, it has been scientifically demonstrated that the common house fly is an active agent in the dissemination of typhoid fever, Asiatic cholera, and other intestinal diseases by carrying the causative organisms of these diseases from the excreta of patients to the food supply of healthy individuals; and that certain species of fleas are the active agents in the conveyance of bubonic plague. Moreover, the tropical disease known as "filariasis" is transmitted by a species of mosquito. Furthermore, it is known that the so-called "spotted fever" of the northern Rocky Mountain regions is carried by a species of tick; and it has been demonstrated that certain blood diseases may be carried by several species of biting insects. The purulent ophthalmia of the Nile Basin is carried by the house fly. A similar disease in the Fiji Islands is conveyed by the same insect. Pink eye in the southern United States is carried by minute flies of the genus *Hippelates*. The house fly has been shown to be a minor factor in the spread of tuberculosis. The bedbug has been connected with the dissemination of several diseases. Certain biting flies carry the sleeping sickness of Africa. A number of dangerous diseases of domestic animals are conveyed by insects. The literature of the whole subject has grown enormously during the past few years, and the economic loss to the human species through these insects is tremendous. At the same time this loss is entirely unnecessary; the diseases in question can be controlled, and the suppression of the conveying insects, so absolutely vital with certain of these diseases and so important in the others, can be brought about.

MOSQUITOES.

Aside from the loss occasioned by these insects as carriers of specific diseases, their abundance brings about a great monetary loss in other ways.

Possibly the greatest of these losses is in the reduced value of real estate in mosquito-infested regions, since these insects render absolutely uninhabitable large areas of land available for suburban homes, for summer resorts, for manufacturing purposes, and for agricultural pursuits. The money loss becomes most apparent in the vicinity of large centers of population. The mosquito-breeding regions in the vicinity of New York City, for example, have prevented the growth of paying industries of various kinds and have hindered the proper development of large regions to an amount which it is difficult to estimate in dollars and cents, and which is almost inconceivable. The same may be said for other large cities near the seacoast, and even of those inland in low-lying regions. The development of the whole State of New Jersey has been held back by the mosquito plague.

Agricultural regions have suffered from this cause. In portions of the Northwestern States it has been necessary to cover work horses in the field with sheets during the day. In the Gulf region of Texas at times the market value of live stock is greatly reduced by the abundance of insects. In portions of southern New Jersey there are lands eminently adapted to the dairying industry, contiguous to the markets of New York, Philadelphia, and the large New Jersey cities. In these localities herds of cattle have been repeatedly established, but the attacks by swarms of mosquitoes have reduced the yield in milk to such an extent as to make the animals unprofitable and dairying has been abandoned for occupations which are normally less remunerative. The condition of thoroughbred race horses at the great racing centers of Sheepshead Bay, Long Island, was so impaired by the attacks of mosquitoes as to induce those interested to spend many thousands of dollars a few years ago in an effort to abate the pest.

All over the United States, for these insects and for the house fly as well, it has become necessary, at great expense, to screen habitations. The cost of screening alone must surely exceed $10,000,000 per annum.

MALARIA.

The West Coast of Africa, portions of India, and many other tropical regions have always, at least down to the present period, been practically uninhabitable by civilized man owing to the presence of pernicious malaria. The industrial and agricultural development of Italy has been hindered to an incalculable degree by the prevalence of malaria in the southern half of the Italian peninsula, as well as in the velley of the Po and elsewhere. The introduction and spread of this disease in Greece is stated by Ronald Ross (and with strong reasons) to have been largely responsible for the progressive physical degeneration of one of the strongest races of the earth.

In the United States malaria, if not endemic, was early introduced. The probabilities are that it was endemic, and it is believed that the cause of failure of the early colonies in Virginia was due to this disease. It is certain that malaria retarded in a marked degree the advance of civilization over the North American Continent, and particularly was this the case in the march of the pioneers throughout the Middle West and throughout the Gulf States to the land west to and beyond the Mississippi. In many large regions once malarious the disease has lessened greatly in frequency and virulence owing to the reclamation of swamp areas and the lessening of the number of the possible breeding places of the malarial mosquitoes, but it is still enormously prevalent, particularly in the Southern States. There are many regions in the North where malaria is unknown, but in some of these localities *Anopheles* mosquitoes breed, and the absence of malaria means simply that malarial patients have not entered the regions at such time of the year as might produce a spread of the malady. It has happened again and again that in communities where malaria was previously unknown it has suddenly made its appearance and spread in a startling manner. These cases are sometimes to be explained, as happened in Brookline, Mass., by the introduction of Italian laborers, some of whom were malarious, to work upon the reservoir, or, as happened at a fashionable summer resort near New York City, by the appearance of a coachman who had had malaria elsewhere and suffered relapse at that place. In such ways, with a rapidly increasing population, malaria is still rapidly spreading in this country.

To attempt an estimate of the economic loss from the prevalence of malaria in the United States is a most difficult task. Prof. Irving Fisher, of Yale University, in one of his papers before the recent International Tuberculosis Congress, declared that tuberculosis costs the people of the United States more than $1,000,000,000 per year. In this estimate Professor Fisher considered the death rate for consumption, the loss of the earning capacity of the patients, the period of invalidism, and the amount of money expended in the care of the sick, together with other factors. In making these estimates he had a much more definite basis than can be gained for malaria. The death rate from malaria is comparatively small, and is apparently decreasing. Exact figures for the whole country are not available. From a table comprising 22 cities it appears that two-thirds of the deaths from malaria occur in the South, one-third only in the North. The death rates, by States, are available only for the following registration States: California, Colorado, Connecticut, District of Columbia, Indiana, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New York, New Jersey, Pennsylvania, Rhode Island, South Dakota, and Vermont, all of which are Northern States. For these States the census reports from 1900 to 1907, inclusive, give the following death rates:

Year.	Number per 100,000 population.	Deaths.
1900	7.9	2,434
1901	6.3	1,791
1902	5.4	1,738
1903	4.3	1,410
1904	4.2	1,391
1905	3.9	1,321
1906	3.5	1,415
1907	2.8	1,166
		12,666

Estimating from the preceding table the average annual death rate at 4.8 per 100,000 population, and considering that the registration area includes only 16 of the Northern States (assuming fairly, however, that the death rate in the other Northern States is the same), it seems reasonably safe to conclude that the death rate from malaria for the whole United States must surely amount to 15 per 100,000. It is probably greater than this, since the statistics from the South are city statistics, and malaria is really a country disease. This would give an annual loss by death from malaria of nearly 12,000 and a total number of deaths for the eight-year period (1900–1907) of approximately 96,000.

But with malaria, perhaps as with no other disease, does the death rate fail to indicate the real loss from the economic point of view. A man may suffer from malaria throughout the greater part of his life, and his productive capacity may be reduced by from 50 to 75 per cent, and yet ultimately he may die from some entirely different cause. In fact the predisposition to death from other causes brought about by malaria is so marked that if in the collection of vital statistics it were possible to ascribe the real influence upon mortality that malaria possesses, this disease would have a very high rank in mortality tables. Writing of tropical countries, Sir Patrick Manson states that malaria causes more deaths and more predisposition to death by inducing cachectic states disposing to other affections than all the other parasites affecting mankind together. Moreover, it has been shown that the average life of the worker in malarious places is shorter and the infant mortality higher than in healthy places.

But aside from this vitally important aspect of the subject the effect of malaria in lessening or destroying the productive capacity of the individual is obviously of the utmost importance, and upon the population of a malarious region is enormous, even under modern conditions and in this country. It has been suggested that the depopulation of the thickly settled Roman Campagna was due to the sudden introduction of malaria by the mercenaries of Sylla and Marius. Celli, in 1900, states that owing to malaria about 5,000,000 acres of land in Italy remain not uncultivated, but certainly very imperfectly cultivated. Then, also, in further example, in quite recent years malaria entered and devastated the islands of Mauritius and Reunion, practically destroying for a time the productiveness of these rich colonies of Great Britain and France.

Creighton, in his article on Malaria in the Encyclopedia Britannica, states that this disease "has been estimated to produce one-half of the entire mortality of the human race; and inasmuch as it is the most frequent cause of sickness and death in those parts of the globe that are most densely populated, the estimate may be taken as at least rhetorically correct."[a]

Is it possible to make any close estimate of the relation between the number of deaths from malaria and the number of cases of the same malady? No perfectly sound basis for such an estimate is apparent. In the English translation of Celli's work on "Malaria according to the new researches," published in London in 1900, it is stated that the mortality from malaria in Italy from 1887 to 1898 varied from 21,033 in the first-named year to 11,378 in the last named, and the mean mortality for the period is assumed to be about 15,000. In

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[a] See Darwinism and Malaria by R. G. Eccles, M. D., Medical Record, New York, January 16, 1909, pp. 85–93.

1896 a count of the patients in the hospitals in Rome was made, and the mortality rate of 7.75 per thousand of the actual patients was established. Calculating, then, on this basis and at this rate the number of cases per year for Italy was placed at about 2,000,000. According to this estimate and with the average mortality for the United States of 12,000, as above indicated, the approximate number of cases for the United States would be about 1,550,000. It seems obvious, however, that Celli, in using the basis of hospital patients only, must have underestimated the number of cases for the kingdom, since of the people in the country suffering from malaria the proportion entering the hospital must be relatively small. Therefore the death rate from malaria of malarial patients in the hospital must be greater than the death rate from malaria of the people who suffer from this disease in the whole country.

In fact so great must this discrepancy necessarily be that it would not seem at all unlikely to the writer if the number of persons suffering from malaria in Italy were in reality nearer 3,000,000 than 2,000,000. The same argument will hold for the United States, and the more especially so since, as a rule, malaria in this country is of a lighter type than in Italy, in fact an estimate of 3,000,000 cases of malaria in the United States annually is probably by no means too high. It will not be an exaggeration to estimate that one-fourth of the productive capacity of an individual suffering with an average case of malaria is lost, and accepting this as a basis, and including the loss through death, the cost of medicines, the losses to enterprises in malarious regions through the difficulty of securing competent labor and other factors, it is safe to place the annual loss to the United States from malarial disease under present conditions at not less than $100,000,000 annually. Celli has shown that in Italy the great railway industries, for example, feel the effect of malaria greatly. According to accurate calculations one company alone, for 1,400 kilometers of railway and for 6,416 workmen in malarious zones, spends on account of malaria 1,050,000 francs a year. The same writer states that the army in Italy from 1877 to 1897 had more than 300,000 cases of malaria.

The loss to this country in the way of retardation of the development of certain regions owing to the presence of malaria is extremely great. Certain territory containing most fertile soil and capable of the highest agricultural productiveness is practically abandoned. With the introduction of proper drainage measures and antimosquito work of other character, millions of acres of untold capacity could be released from the scourge at a comparatively slight expenditure. These regions in the absence of malaria would have added millions upon millions to the wealth of the country. Drainage measures are now being initiated by the Government. Parties of engineers are being sent by the Interior Department to make preliminary drainage surveys in the most prominent of these potentially productive regions. The following statement concerning the effect of malaria on the progress of this work has been made to the writer by Dr. George Otis Smith, Director of the United States Geological Survey:

> In one of the Southern States 11 topographic parties have been at work during the past field season. The full quota for these parties would be 55 men, but I believe that something over 100 men have been employed at different

times during the season. While I have not exact figures before me, I feel warranted in the statement that at least 95 per cent of these employees have been sick for periods ranging from a few days up to two weeks in the hospital. Many of them have been able later to return to work, but at least 30 per cent had to leave the field permanently. By reason of this sickness the efficiency of the parties was reduced, at a very conservative estimate, by 25 per cent.

In my recent visit in this field I found 1 man sick in each of the parties I saw, and 1 man who had just returned from the hospital leaving the field for good. A similar state of things was reported from the other parties. I regard the sickness as practically all of a malarial nature, as extreme care was taken in all the camps to use nothing but boiled water, except in a few instances, where artesian water from great depths was available. In all the camps the tents have been screened, and in every case where the topographer has lived for any time "on the country" there has been infection. As illustrating the value of the precautions generally taken by our camp parties I might cite the fact that last year in West Virginia, with 30 men living in a camp, with typhoid fever prevalent in the neighborhood, no cases developed, while with 6 men living on the country, where the same care could not be taken regarding the water supply, 2 cases of typhoid developed.

In estimating the weight of Doctor Smith's statement it must be borne in mind that the men of his field parties are exceptionally intelligent and prepared to take all ordinary precautions.

Throughout the region in question malaria is practically universal. The railroads suffer, and at the stations throughout the territory it is practically impossible to keep operators steadily at work. This reduction in efficiency in the surveying parties and in the local railroad officials is, moreover, probably very considerably less than the reduction in the earning capacity of the entire population, which, however, is necessarily scanty.

In an excellent paper entitled "The relation of malaria to agricultural and other industries of the South," published in the Popular Science Monthly for April, 1903, Prof. Glenn W. Herrick, then of the College of Agriculture of Mississippi, after a consideration of the whole field, concludes that malaria is responsible for more sickness among the white population of the South than any other disease to which that section is now subject. The following forcible statement, referring to the States of Louisiana, Mississippi, Alabama, Georgia, and South Carolina, is in Professor Herrick's words:

We must now consider briefly what 635,000 or 1,000,000 cases of chills and fevers in one year mean. It is a self-evident truth that it means well for the physician; but for laboring men it means an immense loss of their time, together with the doctors' fees in many instances. If members of their families other than themselves be affected, it may also mean a loss of time, together with the doctors' fees. For the employer it means the loss of labor at a time perhaps when it would be of greatest value. If it does not mean the actual loss of labor to the employer, it will mean a loss in the efficiency of his labor. To the farmers it may mean the loss of their crops by want of cultivation. It will always mean the noncultivation or imperfect cultivation of thousands of acres of valuable land. It means a listless activity in the world's work that counts mightily against the wealth-producing power of the people. Finally it means from two to five million or more days of sickness with all its attendant distress, pain of body, and mental depression to some unfortunate individuals of those five States.

Referring to the Delta region in Mississippi, which lies along the Mississippi River in the western part of the State extending from the mouth of the Yazoo River north nearly to the Tennessee line, Herrick says that it is the second best farming land in the world, having only one rival, and that is the Valley of the Nile. Herrick says:

Still this land to-day, or at least much of it, can be bought at $10 to $20 an acre. Thousands of acres in this region are still covered with the primeval forests, and bears and deer still roaming there offer splendid opportunities for the chase, as evidenced by the late visit of our ex-Chief Executive to those regions for the purpose of hunting. Why is not this land thickly settled? And why is it not worth from $200 to $500 an acre? If it produces from one to two or more bales of cotton on an acre, and it does, it ought to be worth the above-named figures. A bale of cotton to the acre can be produced for $13, leaving a net profit of $20 to $40 for each bale, or $40 to $80 or more for each acre of land cultivated. Moreover, this land has been doing that for years, and will do it for years to come, without the addition of one dollar's worth of fertilizer. Land that will produce a net profit of $40 to $80 an acre is a splendid investment at $100, $200, or even $300 an acre. Yet this land does not sell in the market for anything like so much, because the demand is not sufficient, for white people positively object to living in the Delta on account of malarial chills and fevers. A man said to me not long ago that he would go to the Delta that day if he were sure that his own life or the lives of the members of his family would not be shortened thereby. There are thousands exactly like him, and the only reason that these thousands do not go there to buy lands and make homes is on account of chills and fevers. But there is a time coming, and that not far distant, when malaria in the Delta will not menace the would-be inhabitants. When that time comes it will be the richest and most populous region in the United States.

Malaria is a preventable disease. It is possible for the human species to live, thrive, and produce in malarious regions, but at a very considerable inconvenience and expense. The Italian investigators, and especially Celli and his staff, have shown that by screening the huts of the peasants on the Roman Campagna and by furnishing field laborers with veils and gloves when exposed to the night air it is possible even in that famous hotbed of malaria to conduct farming operations with a minimum of trouble from the disease. Moreover, Koch and his assistants in German East Africa have shown that it is possible, by stamping out the disease among human beings by the free use of medicine, to reach a point where there is small opportunity for malarial mosquitoes to become infected. Moreover, the work of the parties sent out by the Liverpool School of Tropical Medicine and other English organizations to the west coast of Africa has shown that by proper treatment of malarial-mosquito breeding pools the pernicious coast fever may be greatly reduced. Again, the work of Englishmen in the Malay Federated States has shown that large areas may be practically freed from malaria. The most thorough and the most satisfactory of all measures consists in abolishing the breeding places of malarial mosquitoes. In regions like the Delta of Mississippi this involves extensive and systematic drainage, but in very many localities where the breeding places of the *Anopheles* mosquitoes can be easily eradicated, where they are readily located and are so circumscribed as to admit of easy treatment, it is possible to rid the section from malaria at a comparatively slight expense.

With a general popular appreciation of the industrial losses caused primarily by the malarial mosquito and, secondarily, by the nonmalarial carrying forms, as indicated in the opening paragraphs, it is inconceivable that the comparatively inexpensive measures necessary should not be undertaken by the General Government, by the state governments, and by the boards of health of communities, just as it is inconceivable that the individual should suffer from malaria and from the attacks of other mosquitoes when he has individual preventives and remedies at hand. Large-scale drainage measures by the General Government involving large sections of valuable territory have been planned and are practically under way; certain States, notably New Jersey and New York, are beginning to work; communities all over the country through boards of health are also beginning to take notice, while popular education regarding the danger from mosquitoes and in regard to remedial measures is rapidly spreading. But all of this interest should be intensified, and the importance of the work should be displayed in the most emphatic manner, and relief from malarial and other mosquito conditions should be brought about as speedily as possible.

A few excellent examples of antimalarial work may be instanced. The latest reports on the measures taken to abolish malaria from Klang and Port Swettenham in Selangor, Federated Malay States, indicate the most admirable results. These measures were undertaken first in 1901 and 1902 and have been reported upon from time to time in the Journal of Tropical Medicine. The expenditure undertaken by the Government with a view to improving the health of the inhabitants of these towns has been fully justified by the results, which promise to be of permanent value. The total expenditure for the town of Klang, down to the end of 1905, was £3,100, and the annual permanent expenditure is about £60 for clearing earth drains and £210 for town gardeners. For Port Swettenham the total expenditure to the end of 1905 was £7,000, and the annual cost of keeping up the drains, etc., is approximately £40 for clearing earth drains and £100 for town gardeners.

The careful tabulation of cases and deaths and of the results of the examination of blood of children in especially drained areas indicates the following conclusions: (1) Measures taken systematically to destroy breeding places of mosquitoes in these towns, the inhabitants of which suffered terribly from malaria, were followed almost immediately by a general improvement in health and decrease in death rate. (2) That this was due directly to the work carried out and not to a general dying out of malaria in the district is clearly shown by figures, pointing out that while malaria has practically ceased to exist in the areas treated, it has actually increased to a considerable extent in other parts of the district where antimalarial measures have not been undertaken.

The statistics for 1905 are even more favorable than those for 1902, which give a very strong evidence in favor of the permanent nature of the improvement carried out. In fact, it seems that malaria has been permanently stamped out at Klang and Port Swettenham by work undertaken in 1901, and this experience in the Malay States should be of value to those responsible for the health of communities similarly situated in many other parts of the world.

Another striking example of excellent work of this kind is found in the recently published report on the suppression of malaria in Ismaïlia, issued under the auspices of the Compagnie Universelle du Canal Maritime de Suez. Ismaïlia is now a town of 8,000 inhabitants. It was founded by De Lesseps in April, 1862, on the borders of Lake Timsah, which the Suez Canal crosses at middistance between the Red Sea and the Mediterranean. Malarial fever made its appearance in very severe form in September, 1877, although the city had up to that time been very healthful, and increased so that since 1886 almost all of the inhabitants have suffered from the fever. In 1901 an attempt to control the disease was made on the mosquito basis, and this attempt rapidly and completely succeeded, and after two years of work all traces of malaria disappeared from the city. The work was directed not only against *Anopheles* mosquitoes, but against other *Culicids*, and comprised the drainage of a large swamp and the other usual measures. The initial expense amounted to 50,000 francs, and the usual annual expenses since have amounted to about 18,300 francs.

The results may be summarized about as follows: Since the beginning of 1903 the ordinary mosquitoes have disappeared from Ismaïlia. Since the autumn of 1903 not a single larva of *Anopheles* has been found in the protected zone, which extends to the west for a distance of 1,000 meters from the first houses in the Arabian quarter, and to the east for a distance of 1,800 meters from the first houses in the European quarter. After 1902 malarial fever obviously began to decrease, and since 1903 not a single new case of malaria has been found in Ismaïlia.

A very efficient piece of antimalarial work was accomplished in Habana during the American occupation of 1901 and 1902, incidental in a way to the work against yellow fever. An *Anopheles* brigade of workmen was organized under the sanitary officer, Doctor Gorgas, for work along the small streams, irrigated gardens, and similar places in the suburbs, and numbered from 50 to 300 men. No extensive draining, such as would require engineering skill, was attempted, and the natural streams and gutters were simply cleared of obstructions and grass, while superficial ditches were made through the irrigated meadows. Among the suburban truck gardens *Anopheles* bred everywhere, in little puddles of water, cow tracks, horse tracks, and similar depressions in grassy ground. Little or no oil was used by the *Anopheles* brigade, since it was found in practice a simple matter to drain these places. At the end of the year it was very difficult to find water containing mosquito larvæ anywhere in the suburbs, and the effect upon malarial statistics was striking. In 1900, the year before the beginning of the mosquito work, there were 325 deaths from malaria; in 1901, the first year of the mosquito work, 171 deaths; in 1902, the second year of mosquito work, 77 deaths. Since 1902 there has been a gradual though slower decrease, as follows: 1903, 51; 1904, 44; 1905, 32; 1906, 26; 1907, 23. These results, although less striking than those from Ismaïlia, involved a smaller expense in money and show surely an annual saving of 300 lives, and undoubtedly a corresponding decrease in the number of malarial cases, which may be estimated upon our earlier basis at something less than 40,000.

YELLOW FEVER.

Yellow fever has prevailed endemically throughout the West Indies and in certain regions on the Spanish Main virtually since the discovery of America. The Barbados, Jamaica, and Cuba suffered epidemics before the middle of the seventeenth century. There were outbreaks in Philadelphia, Charleston, and Boston as early as 1692, and for a hundred years there were occasional outbreaks, culminating in the great Philadelphia epidemic of 1793. Northern cities were able by rigid quarantine measures to prevent great epidemics after the early part of the nineteenth century, but from the West Indies the disease was occasionally introduced and prevailed from time to time epidemically in the Southern States. In 1853 it raged throughout this region, New Orleans alone having a mortality of 8,000. The last widespread epidemic occurred in 1878, chiefly in Louisiana, Alabama, and Mississippi, but spreading up the Mississippi Valley as far as Cairo, Ill., attacking with virulence the city of Memphis, Tenn. In this year there were 125,000 cases and 12,000 deaths. In 1882 there were 192 deaths at Pensacola; in 1887, 62 deaths in the Southern States; in 1893, 52 deaths; in 1897, 484; in 1898, 2,456 cases, with 117 deaths; in 1903, 139 deaths were recorded, mostly at Laredo, Tex.; and in 1905 there was a serious outbreak at New Orleans and in neighboring towns, including one locality in Mississippi, in which 911 deaths were recorded for the whole country.

The actual loss of life from yellow fever during all these years, when compared to the loss from other diseases, has been comparatively slight, but the death rate is perhaps the most insignificant feature of the devastation which yellow-fever epidemics have produced, and the disease itself has been but a small part of the affliction which it has brought to the Southern States. The disease once discovered in epidemic form, the whole country has become alarmed; commerce in the affected region has come virtually to a standstill; cities have been practically deserted; people have died from exposure in camping out in the highlands; rigid quarantines have been established; innocent persons have been shot while trying to pass these quarantine lines; all industry for the time has ceased. The commerce of the South during the epidemic of 1878, for example, fell off 90 per cent, and the hardships of the population can not be estimated in monetary terms. With such industrial and commercial conditions existing from Texas to South Carolina, many industries at the North have suffered, and, in fact, the effect of a yellow-fever summer in the South has been felt not only all over the United States, but in many other portions of the world.

All these conditions, as bad as they have been, do not sum up the total loss to the national prosperity during past years. Cities like Galveston, New Orleans, Mobile, Memphis, Jacksonville, and Charleston, subject to occasional epidemics, as they have been in the past, have not prospered as they should. Their progress has been greatly impeded by this one cause, and thus the industrial development of the entire South has been greatly retarded.

Physicians had been theorizing about the cause of yellow fever from the time when they began to treat it. It was thought by many that it was carried in the air; by others that it was conveyed by the clothing, bedding, or other articles which had come in contact with a yellow-fever patient. There were one or two early suggestions of the agency of mosquitoes, but practically no attention was paid to them, and they have been resurrected and considered significant only since the beginning of the present century. With the discovery of the agency of micro-organisms in the causation of disease, a search soon began for some causative germ. Many micro-organisms were found in the course of the autopsies and many claims were put forth by investigators. All of these, however, were virtually set at rest by Sternberg in his "Report on the Etiology and Prevention of Yellow Fever," published in 1890, but a claim made by Sanarelli in June, 1897, for a bacillus which he called *Bacillus icteroides* received considerable credence, and in 1899 it was accepted in full by Wasden and Geddings, of the Marine-Hospital Service, who reported that they had found this bacillus in 13 or 14 cases of yellow fever in the city of Habana. There is no evidence, however, that this bacillus has anything to do with yellow fever. In 1881 Finlay, of Habana, proposed the theory that yellow fever whatever its cause may be is conveyed by means of *Culix* (now *Stegomyia*) *fasciatus* (now *calopus*). Subsequently he published several important papers in which his views were modified from time to time, and in the course of which he mentioned experiments with 100 individuals, producing 3 cases of mild fever. None of the cases, however, was under his full control, and the possibility of other methods of gaining the disease was not excluded. Therefore his theory, while it was received with interest, was not considered to be proved.

In 1890 came the beginning of the true demonstration. An army board was appointed by Surgeon-General Sternberg for the purpose of investigating the acute infectious diseases prevailing in the island of Cuba. The result achieved by this board, consisting of Reed, Carroll, Lazear, and Agramonte, was a demonstration that yellow fever is carried by *Stegomyia calopus*, and their ultimate demonstration was so perfect as to silence practically all expert opposition. The Third International Sanitary Convention of the American Republics unanimously accepted the conclusion that yellow fever is carried by this mosquito and that the *Stegomyia* constitutes the only known means by which the disease is spread. To-day, after abundant additional demonstration, the original contention of Reed, Carroll, and Agramonte (Lazear having died in the course of the experiments) is a part of the accepted knowledge of the medical world. The importance of the discovery can not be overestimated, and its first demonstration was followed by antimosquito measures in the city of Habana, undertaken, under the direction of Gorgas, with startling results.

Yellow fever had been endemic in Habana for more than one hundred and fifty years, and Habana was the principal source of infection for the rest of Cuba. Other towns in the island could have rid themselves of the disease if they had not been constantly reinfected from Habana. By ordinary sanitary measures of cleanliness, improved drainage, and similar means the death rate of the city was improved from an average of 40 per thousand under Spanish rule to 22 per thousand in 1900, but these measures had no effect upon yellow fever, this disease increasing as the nonimmune population following the Spanish war increased.

Stegomyia calopus was established as the carrier of the fever early in 1901, and then antimosquito measures were immediately begun. Against adult mosquitoes no general measures were attempted, although screening and fumigation were carried out in quarters occupied by yellow-fever patients. It was found that the *Stegomyia* bred principally in the rain-water collections in the city itself. The city was divided into about 30 districts, and to each district an inspector and two laborers were assigned—each district containing about a thousand houses. An order was issued by the mayor of Habana requiring all collections of water to be so covered that mosquitoes could not have access, a fine being imposed in cases where the order was not obeyed. The health department covered the rainwater barrels of poor families at public expense. All cesspools were treated with petroleum. All receptacles containing fresh water which did not comply with the law were emptied and on the second offense destroyed. The result of this work thoroughly done was to wipe out yellow fever in Habana, and for four years there was not a case in Habana or in Cuba.

In what is termed the "New Orleans epidemic of 1905," a striking illustration of the value of this recently acquired mosquito-transmission knowledge is seen. The presence of yellow fever in the city was first recognized about the 1st of July, but it was the 12th of August before the Public Health and Marine-Hospital Service was put in complete control of the situation. By that time the increase in new cases and deaths rendered it practically certain that the disease was as widespread as during the terrible epidemic of 1878. There had been up to that date 142 deaths from a total of 913 cases, as against 152 deaths from a total of 519 cases in 1878. The Public Health and Marine-Hospital Service, under Doctor White, took hold of the situation with energy, basing its measures almost entirely upon a warfare against *Stegomyia calopus.* The disease began almost immediately to abate, and the result at the close of the season indicated 460 deaths, as against 4,046 in 1878, a virtual saving of over 3,500 lives. The following table of deaths from yellow fever in New Orleans from 1847 to 1905 points out most strikingly the value of this antimosquito work:

Comparative table of deaths from yellow fever in New Orleans.

Months.	1847.	1848.	1853.	1854.	1855.	1858.	1867.	1878.	1905.
May	....	....	2						
June	....	4	31	2	5	2	3	....	....
July	74	33	1,521	29	382	132	11	26	35
August	965	200	5,133	532	1,286	1,140	255	1,025	236
September	1,100	467	982	1,234	874	2,204	1,637	1,780	107
October	198	126	147	490	97	1,137	1,072	1,065	59
November	12	20	28	131	19	224	103	147	23
December	10	....	4	7	7	15	26	3	....
Months unknown	445	22	....	....	....	....	....	....	....
Total	2,804	872	7,848	2,425	2,670	4,854	3,107	4,046	460

The epidemics of 1848, 1854, and 1855 are least comparable with that of 1905, because they immediately succeed severe epidemics to which were due very many immunes.

Population of New Orleans by United States Census: 130,565 in 1850; 168,675 in 1860; 191,418 in 1870; 216,090 in 1880; and 287,104 in 1900.

WORK ON THE ISTHMUS OF PANAMA.

The United States Government has very properly used the services of Colonel Gorgas, who was in charge of the eminently successful work at Habana, by appointing him chief sanitary officer of the Canal Zone during the digging of the canal. In 1904 active work was begun, and Colonel Gorgas was fortunate in having the services of Mr. Le Prince, who had been chief of his mosquito brigades in Habana, and therefore was perfectly familiar with antimosquito methods. In Panama, the population had depended principally upon rain water for domestic purposes, so that every house had cisterns, water barrels, and such receptacles for catching and storing rain water. The city was divided into small districts with an inspector in charge of each district. This inspector was required to cover his territory at least twice a week and to make a report upon each building with regard to its condition as to breeding places of mosquitoes. All the cisterns, water barrels, and other water receptacles in Panama were covered as in Habana, and in the water barrels spigots were inserted so that the covers would not have to be taken off. Upon first inspection, in March, 4,000 breeding places were reported. At the end of October less than 400 containing larvæ were recorded. This gives one a fair idea of the consequent rapid decrease in the number of mosquitoes in the city. These operations were directed primarily against the yellow-fever mosquito, and incidentally against the other common species that inhabit rain-water barrels. Against the *Anopheles* in the suburbs the same kind of work was done as in Habana, with exceptionally good results.

The same operations were carried on in the villages between Panama and Colon. There are some twenty of these, running from 500 to 3,000 inhabitants each. Not a single instance of failure has occurred in the disinfection of these small towns, and the result of the work has been the apparent elimination of yellow fever and the very great reduction of malarial fever. The remarkable character of these results can only be judged accurately by comparative methods. It is well known that during the French occupation there was an enormous mortality among European employees, and this was a vital factor in the failure of the work. Exact losses can not be estimated, since the work was done under 17 different contractors. These contractors were charged $1 a day for every sick man to be taken care of in the hospital of the company. Therefore it often happened that when a man became sick his employer discharged him so that he would not have to bear the expense of hospital charges. There was no police patrol of the territory. A great many of these men were found to have died along the roadside while endeavoring to find their way to the city of Panama. Colonel Gorgas has stated that the English consul, who was at the Isthmus during the period of the French construction, is inclined to think that more deaths of employees occurred out of the hospital than in it. The old superintendent of the French hospital states that one day 3 of the medical staff died from yellow fever, and in the same month 9 of the medical staff. Thirty-six Roman Catholic sisters were brought over as nurses, of whom 24 died of yellow fever. On one vessel 18 young French engineers came over, and within a month all but 1 died.

Now that the relation of the mosquito to yellow fever is well understood, it was found during the first two years under Colonel Gorgas that although there were constantly one or more yellow-fever cases in the hospital, and although the nurses and physicians were all nonimmunes, not a single case of yellow fever was contracted in that way. The nurses never seemed to consider that they were running any risk in attending yellow-fever cases night and day in screened wards, and the wives and families of officers connected with the hospital lived about the grounds, knowing that yellow fever was constantly being brought into the grounds and treated in near-by buildings. Americans, sick from any cause, had no fear of being treated in beds immediately adjoining those of yellow-fever patients. Colonel Gorgas and Doctor Carter lived in the old ward used by the French for their officers, and Colonel Gorgas thinks it safe to say that more men had died from yellow fever in that building under the French régime than in any other building of the same capacity at present standing. He and Doctor Carter had their wives and children with them, which would formerly have been considered the height of recklessness; but they looked upon themselves, under the now recognized precautions, almost as safe as they would have been in Philadelphia or Boston.

No figures of actual cost of the antimosquito work, either in Habana or in the Panama Canal Zone, are accessible to the writer, but it is safe to say that it was not exorbitant, and that it was not beyond the means of any well-to-do community in tropical regions.

THE TYPHOID FLY, COMMONLY KNOWN AS THE "HOUSE FLY."

The name "typhoid fly" is here proposed as a substitute for the name "house fly," now in general use. People have altogether too long considered the house fly as a harmless creature, or, at the most, simply a nuisance. While scientific researches have shown that it is a most dangerous insect from the standpoint of disease, and while popular opinion is rapidly being educated to the same point, the retention of the name "house fly" is considered inadvisable as perpetuating in some degree the old ideas. Strictly speaking, the term "typhoid fly" is open to some objection as conveying the erroneous idea that this fly is solely responsible for the spread of typhoid; but considering that the insect is dangerous from every point of view, and that it is an important element in the spread of typhoid, it seems advisable to give it a name which is almost wholly justified and which conveys in itself the idea of serious disease. Another repulsive name that might be given to it is the "manure fly;" but recent researches have shown that it is not confined to manure as a breeding place, although perhaps the great majority of these flies are so propagated. For the end in view "typhoid fly" is considered the best name.

The true connection and the true scientific evidence regarding the rôle of the so-called "house fly" with typhoid fever has only recently been worked out. Celli, in 1888, fed flies with pure cultures of the *Bacillus typhi-abdominalis*, and examined their contents and dejections microscopically and culturally. Inoculations of animals were also made, proving that the bacilli which passed through flies were virulent. Dr. George M. Kober, who is familiar with Celli's researches, in his report on the prevalence of typhoid fever in the District of Columbia, published in 1895, called especial attention to the danger of the contamination of food supplies by flies coming from the excreta of typhoid patients. The prevalence of typhoid fever in the concentration camps of the United States Army in the summer of 1898 brought about the appointment of an army typhoid commission, consisting of Dr. Walter Reed, U. S. Army; Dr. Victor M. Vaughan, U. S. Volunteers; and Dr. E. O. Shakespeare, U. S. Volunteers. A paper read by Doctor Vaughan before the annual meeting of the American Medical Association at Atlantic City, N. J., June 6, 1900, contained the following conclusions with regard to flies:

27. *Flies undoubtedly served as carriers of the infection.*—My reasons for believing that flies were active in the dissemination of typhoid may be stated as follows:

"*a.* Flies swarmed over infected fecal matter in the pits and then visited and fed upon the food prepared for the soldiers at the mess tents. In some instances where lime had recently been sprinkled over the contents of the pits, flies with their feet whitened with lime were seen walking over the food.

"*b.* Officers whose mess tents were protected by means of screens suffered proportionately less from typhoid fever than did those whose tents were not so protected.

"*c.* Typhoid fever gradually disappeared in the fall of 1898, with the approach of cold weather, and the consequent disabling of the fly.

"It is possible for the fly to carry the typhoid bacillus in two ways. In the first place, fecal matter containing the typhoid germ may adhere to the fly and be mechanically transported. In the second place, it is possible that the typhoid bacillus may be carried in the digestive organs of the fly and may be deposited with its excrement."

There were also many important conclusions which bear upon the fly question. For example, it was shown that every regiment in the United States service in 1898 developed typhoid fever, nearly all of them within eight weeks after assembling in camps. It not only appeared in every regiment in the service, but it became epidemic both in small encampments of not more than one regiment and in the larger ones consisting of one or more corps. All encampments located in the Northern, as well as in the Southern States, exhibited typhoid in epidemic form. The miasmatic theory of the origin of typhoid fever and the pythogenic theory[a] were not supported by the investigations of the commission, but the doctrine of the specific origin of fever was confirmed. The conclusion was reached that the fever is disseminated by the transference of the excretions of an infected individual to the alimentary canals of others, and that a man infected with typhoid fever may scatter the infection in every latrine or regiment before the disease is recognized in himself, while germs may be found in the excrement for a long time after the apparently complete recovery of the patient. Infected water was not an important factor in the spread of typhoid in the national encampments of 1898, but about one-fifth of the soldiers in the national encampments in the United States during that summer developed this disease, while more than 80 per cent of the total deaths were caused by typhoid.

In 1899 the writer began the study of the typhoid or house fly under both country and city conditions. He made a rather thorough investigation of the insect fauna of human excrement, and made a further investigation of the species of insects that are attracted to food supplies in houses. In a paper entitled "A contribution to the study of the insect fauna of human excrement (with especial reference to the spread of typhoid fever by flies)," published in the Proceedings of the Washington Academy of Sciences, Volume II, pages 541–604, December 28, 1900, he showed that 98.8 per cent of the whole number of insects captured in houses throughout the whole country under the conditions indicated above were *Musca domestica*, the typhoid or house fly. He showed further that this fly, while breeding most numerously in horse stables, is also attracted to human excrement and will breed in this substance. It was shown that in towns where the box privy was still in existence the house fly is attracted to the excrement, and, further, that it is so attracted in the filthy regions of a city where sanitary supervision is lax and where in low alleys and corners and in vacant lots excrement is deposited. He stated that he had seen excrement which had been deposited overnight in an alleyway in south Washington swarming with flies under the bright sunlight of a June morning (temperature 92° F.), and that within 30 feet of these deposits were the open windows and doors of the kitchens of two houses kept by poor people, these two houses being only elements in a long row. The following paragraph is quoted from the paper just cited:

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[a] This theory is founded upon the belief that the colon germ may undergo a ripening process by means of which its virulence is so increased and altered that it may be converted into the typhoid bacillus, or at least may become the active agent in the causation of typhoid fever.

> Now, when we consider the prevalence of typhoid fever and that virulent typhoid bacilli may occur in the excrement of an individual for some time before the disease is recognized in him and that the same virulent germs may be found in the excrement for a long time after the apparent recovery of a patient, the wonder is not that typhoid is so prevalent but that it does not prevail to a much greater extent. Box privies should be abolished in every community. The depositing of excrement in the open within town or city limits should be considered a punishable misdemeanor in communities which have not already such regulations, and it should be enforced more rigorously in towns in which it is already a rule. Such offenses are generally committed after dark and it is often difficult or even impossible to trace the offender; therefore the regulation should be carried even further and require the first responsible person who notices the deposit to immediately inform the police so that it may be removed or covered up. Dead animals are so reported, but human excrement is much more dangerous. Boards of health in all communities should look after the proper treatment or disposal of horse manure, primarily in order to reduce the number of house flies to a minimum, and all regulations regarding the disposal of garbage and foul matter should be made more stringent and should be more stringently enforced.

In the opening sentence of the paragraph just quoted attention was called to the activity of bacilli in excreta passed by individuals after apparent recovery from typhoid. Since the paper in question was published more especial attention has been drawn by medical men to this point, and it has been shown that individuals who are chronic spreaders of the typhoid germs are much more abundant than was formerly supposed. Dr. George A. Soper recently discovered a striking case of this kind in the person of a cook employed successively by several families in the vicinity of New York City, with the result that several cases of typhoid occurred in each of these families. In a paper by Doctor Davies and Professor Walker, read before the Royal Sanitary Institute of London during the present season, the history was given of four personal carriers of typhoid who had communicated the disease to a number of people. These four carriers were detected in one city within a few months, and from this fact it can be argued with justice that such cases are comparatively numerous. This being the case, the danger of unguarded miscellaneous human excreta deposited in city suburbs, in vacant lots, in low alleyways, intensifies to a very marked degree the danger of food contamination with typhoid bacilli by means of the typhoid or house fly. It is well known, too, that the urine of persons who have suffered from typhoid fever often contains typhoid bacilli for several weeks after the patients have recovered; consequently, this also is a source of danger.

The importance of the typhoid fly as a carrier of the disease in army camps, as shown in the Spanish war and in the Boer war and in the camps of great armies of laborers engaged in gigantic enterprises like the digging of the Panama Canal, is obvious, but what has just been stated indicates that even under city conditions the influence of this fly in the spread of this disease has been greatly underestimated. It is not claimed that under city conditions the house fly becomes by this argument a prime factor in the transfer of the disease, but it must obviously take a much higher relative rank among typhoid conveyers than it has hitherto assumed. Perhaps even under city conditions it must assume third rank—next to water and milk.

It is not alone as a carrier of typhoid that this fly is to be feared. In the same way it may carry nearly all intestinal diseases. It is a prime agent in the spreading of summer dysentery, and in this way is unquestionably responsible for the death of many children in summer. One of the earliest accurate scientific studies of the agency of insects in the transfer of human disease was in regard to flies as spreaders of cholera. The belief in this agency long preceded its actual proof. Dr. G. E. Nicholas, in the London Lancet,[a] is quoted by Nuttall as writing, in 1849, when cholera prevailed at Malta:

> My first impression of the possibility of the transfer of the disease by flies was derived from the observation of the manner in which these voracious creatures, present in great numbers and having equal access to the dejections and food of patients, gorged themselves indiscriminately and then disgorged themselves on the food and drinking utensils. In 1850 the *Superb*, in common with the rest of the Mediterranean squadron, was at sea nearly six month. During the greater part of the time she had cholera on board. On putting to sea, the flies were in great force; but after a time they gradually disappeared and the epidemic slowly subsided. On going into Malta Harbor, but without communicating with the shore, the flies returned in greater force and the cholera also with increased violence. After more cruising at sea the flies disappeared gradually with the subsidence of the disease.

Accurate scientific bacteriological observations by Tizzoni and Cattani in 1886 showed definitely active cholera organisms in the dejecta of flies caught in the cholera wards in Bologna. These observations were subsequently verified and extended by Simonds, Offelmann, Macrae, and others.

With tropical dysentery and other enteric diseases practically the same conditions exist. In a report by Daniel D. Jackson to the committee on pollution of the Merchants' Association in New York, published in December, 1907, the results of numerous observations upon the relation of flies to intestinal disease are published, and the relation of deaths from intestinal diseases in New York City to the activity and prevalence of the common house fly is shown not only by repeated observations, but also by an interesting plotting of the curve of abundance of flies in comparison with the plotted curve of abundance of deaths from intestinal diseases, indicating that the greatest numbers of flies occurred in the weeks ending July 27 and August 3; that the deaths from intestinal diseases rose above the normal at the same time at which flies became prevalent, culminated at the same high point, and fell off with slight lag at the time of the gradual falling off of the prevalence of the insects.

Similar studies have been carried on during the summer of 1908 in the city of Washington, and the curve of typhoid fly abundance for the whole city as well as that for a district comprising eight city squares, in which intensive studies have been made both of flies and of disease, will be plotted at the close of the season. At the time of writing this work has not been completed.

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[a] Volume II, 1873, p. 724.

The typhoid fly also possesses importance as a disseminator of the bacilli of tuberculosis. In a paper by Dr. Frederick T. Lord, of Boston,[a] the following conclusions are reached:

> **1. Flies may ingest tubercular sputum and excrete tubercle bacilli, the virulence of which may last for at least fifteen days.**
>
> **2. The danger of human infection from tubercular flyspecks is by the ingestion of the specks on food. Spontaneous liberation of tubercle bacilli from flyspecks is unlikely. If mechanically disturbed, infection of the surrounding air may occur.**
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> **As a corollary to these conclusions it is suggested that—**
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> **3. Tubercular material (sputum, pus from discharging sinuses, fecal matter from patients with intestinal tuberculosis, etc.) should be carefully protected from flies lest they act as disseminators of the tubercle bacilli.**
>
> **4. During the fly season greater attention should be paid to the screening of rooms and hospital wards containing patients with tuberculosis and laboratories where tubercular material is examined.**
>
> **5. As these precautions would not eliminate fly infection by patients at large, foodstuffs should be protected from flies which may already have ingested tubercular material.**

From all these facts it appears that the most important part played by the typhoid fly or house fly in the human economy is to carry bacteria from one place to another. The following table and comments are taken from Bulletin No. 51 (April, 1908) of the Storrs Agricultural Experiment Station, Storrs, Conn., entitled "Sources of Bacteria in Milk," by W. M. Esten and C. J. Mason.

Sources of bacteria from flies.

Date.	Source.	Total number.	Total acid bacteria.	Rapid liquefying bacteria.	Slow liquefying bacteria.	Bacterium lactis acidi (Group A, Class 1).	Coli-aerogenes (Group A, Class 2).
1907. July 27	(*a*) 1 fly, bacteriological laboratory	3,150	250	600	100	....	....
July 27	(*b*) 1 fly, bacteriological laboratory	550	100	0	0	....	....
Aug. 6	(*c*) 19 cow stable flies	7,980,000	220,000	0	20,000	....	....
	Average per fly.	420,000	11,600	0	1,000	....	....
Aug. 14	(*d*) 94 swill barrel flies	155,000,000	8,950,000	0	0	4,320,000	4,630,000
	Average per fly.	1,660,000	95,300	0	0	46,000	49,300
Aug. 14	(*e*) 144 pig pen flies.	133,000,000	2,110,000	100,000	266,000	933,000	1,176,000
	Average per fly.	923,000	18,700	700	1,150	6,500	12,200
Sept. 4	(*f*) 18 swill barrel flies	118,800,000	40,480,000	0	14,500,000	10,480,000	30,000,000
	Average per fly.	6,600,000	2,182,000	0	804,000	582,000	1,600,000
Sept. 21	(*g*) 30 dwelling house flies	1,425,000	125,000	0	12,500	....	....
	Average per fly.	47,580	4,167	0	417	....	....
Sept. 21	(*h*) 26 dwelling house flies	22,880,000	22,506,000	120,000	34,000	....	....
	Average per fly.	880,000	869,000	4,600	1,300	....	....

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[a] Reprinted from the Boston Medical and Surgical Journal for Dec. 15, 1904, pp. 651–654.

Sources of bacteria from flies—Continued.

Date.	Source.	Total number.	Total acid bacteria.	Rapid liquefying bacteria.	Slow liquefying bacteria.	Bacterium lactisacidi (Group A, Class 1).	Coli-aerogenes (Group A, Class 2).
1907. Sept. 27	(*i*) 110 dwelling house flies........	35,500,000	13,670,000	8,840,000	125,000	....	....
	Averageperfly.	322,700	124,200	80,300	1,100	....	....
Aug. 20	(*j*) 1 large blue bottle blow fly.......	308,700	(a)	....	....	....	....
	Total average of 414 flies...	1,222,570	367,800	7,830	73,500	....	....
	Average percentage of 414 flies......	....	30	6	6	....	....
	Averageperfly of 256 flies, experiments (*d*), (*e*), and (*f*)...........	3,061,000	765,000	230	268,700	211,500	553,800
	Average per cent of 256 flies, experiments (*d*), (*e*), and (*f*)..	....	25	....	8	7	18

[a] 2,200 mold spores.

From the above table the bacterial population of 414 flies is pretty well represented, the domestic fly passing from a disgusting nuisance and troublesome pest to a reputation of being a dangerous enemy to human health. A species of mosquito has been demonstrated to be the cause of the spread of malaria. Another kind of mosquito is the cause of yellow fever, and now the house fly is considered an agency in the distribution of typhoid fever, summer complaint, cholera infantum, etc.

The numbers of bacteria on a single fly may range all the way from 550 to 6,600,000. Early in the fly season the numbers of bacteria on flies are comparatively small, while later the numbers are comparatively very large. The place where flies live also determines largely the numbers that they carry. The average for the 414 flies was about 1,250,000 bacteria on each. It hardly seems possible for so small a bit of life to carry so large a number of organisms. The method of the experiment was to catch the flies from the several sources by means of a sterile fly net, introduce them into a sterile bottle, and pour into the bottle a known quantity of sterilized water, then shake the bottle to wash the bacteria from their bodies, to simulate the number of organisms that would come from a fly in falling into a lot of milk. In experiments (*d*), (*e*), and (*f*) the bacteria were analyzed into four groups. The objectionable class, coli-aerogenes type, was 2½ times as abundant as the favorable acid type. If these flies stayed in the pigpen vicinity there would be less objection to the flies and the kinds of organisms they carry, but the fly is a migratory insect, and it visits everything "under the sun." It is almost impossible to keep it out of our kitchens, dining rooms, cow stables, and milk rooms. The only remedy for this rather serious condition of things is to remove the pigpen as far as possible from the dairy and dwelling house. Extreme care should be taken in keeping flies out of the cow stable, milk rooms, and dwellings. Flies walking over our food are the cause of one of the worst contaminations that could occur from the standpoint of cleanliness and the danger of distributing disease germs.

The danger of the typhoid or house fly in the carriage of disease has thus been abundantly demonstrated. Further than this, it is an intolerable nuisance. With mosquitoes, it necessitates an annual outlay for window and door screens in the United States of not less than $10,000,000. As a carrier of disease it causes a loss of many millions of dollars annually. Dr. G. M. Kober, in a paper prepared for the governors' conference on the conservation of natural resources, held at the White House in May, 1908, entitled "The conservation of life and health by improved water supply," presented figures showing that the decrease in the vital assets of the country through typhoid fever in a single year is more than $350,000,000. The house fly, as an important agent in the spread of this disease, is responsible for a very considerable portion of this decrease in vital assets. As an agency in the spread of other intestinal diseases, this sum must be greatly increased, and yet the fly is allowed to breed unrestricted all over the United States; it is allowed to enter freely the houses of the great majority of our people; it is allowed to spread bacteria freely over our food supplies in the markets and in the kitchens and dining rooms of private houses; and, to use the happy phraseology of Dr. Theobald Smith, "When we go into public restaurants in midsummer, we are compelled to fight for our food with the myriads of house flies which we find there, alert, persistent, and invincible."

Even if the typhoid or house fly were a creature difficult to destroy, the general failure on the part of communities to make any efforts whatever to reduce its numbers could properly be termed criminal neglect, but since, as will be shown, it is comparatively an easy matter to do away with the plague of flies, this neglect becomes an evidence of ignorance or of a carelessness in regard to disease-producing filth which to the informed mind constitutes a serious blot on civilized methods of life.

Strange as it may seem, an exhaustive study of the conditions which produce house flies in numbers has never been made. The life history of the insect in general was, down to 1873, mentioned in only three European works and few exact facts were given. In 1873 Dr. A. S. Packard, then of Salem, Mass., studied the transformations of the insect and gave descriptions of all stages, showing that the growth of a generation from the egg state to the adult occupies from ten to fourteen days.

In 1895 the writer traced the life history in question, indicating that 120 eggs are laid by a single female, and that in Washington in midsummer a generation is produced every ten days. Although numerous substances were experimented with, he was able to breed the fly only in horse manure. Later investigations indicated that the fly will breed in human excrement and in other fermenting vegetable and animal material, but that the vast majority of the flies that infest dwelling houses both in cities and on farms come from horse manure.

In 1907 careful investigations carried on in the city of Liverpool by Robert Newstead, lecturer in economic entomology and parasitology in the School of Tropical Medicine of the University of Liverpool, indicated that the chief breeding places of the house fly in that city should be classified under the following heads: (1) Middensteads (places where dung is stored) containing horse manure only; (2) middensteads containing spent hops; (3) ash pits containing fermenting materials.

He found that the dung heaps of stables containing horse manure only were the chief breeding places. Where horse and cow manures were mixed, the flies bred less numerously, and in barnyards where fowls were kept and allowed freedom relatively few house flies were found. Only one midden containing warm spent hops was inspected, and this was found to be as badly infested as any of the stable middens. A great deal of time was given to the inspection of ash pits, and it was found that wherever fermentation had taken place and artificial heat had been thus produced such places were infested with house fly larvæ and pupæ often to the same alarming extent as in stable manure. Such ash pits as these almost invariably contained large quantities of old bedding or straw and paper, paper mixed with human excreta, or old rags, manure from rabbit hutches, etc., or a mixture of all these. About 25 per cent of the ash pits examined were thus infested, and house flies were found breeding in smaller numbers in ash pits in which no heat had been engendered by fermentation. The house fly was also found breeding by Mr. Newstead in certain temporary breeding places, such as collections of fermenting vegetable refuse, accumulations of manure at wharves, and in bedding in poultry pens.

Still more recent investigations have been carried on during the year 1908 by Prof. S. A. Forbes, state entomologist of Illinois, who has reared it in large numbers from the contents of paunches of slaughtered cattle, from refuse hog hairs, from tallow vats, from carcasses of various animals, miscellaneous garbage, and so on.

All this means that if we allow the accumulation of filth we will have house flies, and if we do not allow it to accumulate we will have no house flies. With the careful collection of garbage in cans and the removal of the contents at more frequent intervals than ten days, with the proper regulation of abattoirs, and particularly with the proper regulations of stables in which horses are kept, the typhoid fly will become a rare species. It will not be necessary to treat horse manure with chloride of lime or with kerosene or with a solution of paris green or arsenate of lead, if stable men are required to place the manure daily in a proper covered receptacle and it is carried away once a week.

The orders of the health department of the District of Columbia, published May 3, 1906, if carried out, will be very effective. These orders may briefly be condensed as follows:

> All stalls in which animals are kept shall have the surface of the ground covered with a water-tight floor. Every person occupying a building where domestic animals are kept shall maintain, in connection therewith, a bin or pit for the reception of manure, and pending the removal from the premises of the manure from the animal or animals, shall place such manure in said bin or pit. This bin shall be so constructed as to exclude rain water, and shall in all other respects be water-tight except as it may be connected with the public sewer. It shall be provided with a suitable cover and constructed so as to prevent the ingress or egress of flies. No person owning a stable shall keep any manure or permit any manure to be kept in or upon any portion of the premises other than the bin or pit described, nor shall he allow any such bin or pit to be overfilled or needlessly uncovered. Horse manure may be kept tightly rammed into well-covered barrels for the purpose of removal in such barrels. Every person keeping manure in any of the more densely populated parts of the District shall cause all such manure to be removed from the premises at least twice every week between June 1 and October 31, and at least once every week between November 1 and May 31 of the following year. No person shall remove or transport any manure over any public highway in any of the more densely populated parts of the District except in a tight vehicle which, if not inclosed, must be effectually covered with canvas so as to prevent the manure from being dropped. No person shall deposit manure removed from the bins or pits within any of the more densely populated parts of the District without a permit from the health officer. Any person violating any of these provisions shall, upon conviction thereof, be punished by a fine of not more than $40 for each offense.

In addition to this excellent ordinance, others have been issued from the health department of the District of Columbia which provide against the contamination of exposed food by flies and by dust. The ordinances are excellently worded so as to cover all possible cases. They provide for the registration of all stores, markets, cafes, lunch rooms, or of any other place where food or beverage is manufactured or prepared for sale, stored for sale, offered for sale, or sold, in order to facilitate inspection, and still more recent ordinances provide for the registration of stables. An excellent campaign was begun during the summer of 1908 against insanitary lunch rooms and restaurants. A number of cases were prosecuted, but conviction was found to be difficult.

For one reason or another, the chief reason being the lack of a sufficient force of inspectors under the control of the health officer, the ordinance in regard to stables has not been carried out with that perfection which the situation demands. In the summer of 1896 the health officer of the District, Dr. W. C. Woodward, designated a region in Washington bounded by Pennsylvania avenue, Sixth street, Fifteenth street, and the Potomac River, which was to be watched by assistants of the writer. Twenty-four stables were located in this region and were visited weekly by two assistants chosen for the purpose. The result was that on the whole the manure was well looked after and the number of flies in the region in question was very considerably reduced during the time of inspection.

Were simple inspection of stables all that is needed, a force of four inspectors, especially detailed for this work, could cover the District of Columbia, examining once a week all the stables after they had been once located and mapped. The average salary of an inspector is $1,147, so that the total expense for the first year would be about $4,500. But the inspectors' service is complicated by the matter of prosecution. Much of the time of inspectors would be taken in the prosecution of the owners of neglected premises. Moreover, the health officer has found during the summer of 1908 in his prosecution of the owners or managers of insanitary restaurants that his inspectors were practically sworn out of court by the multiplicity of opposing evidence. This means that it will be necessary in such cases to send two inspectors together in all cases, so that the testimony of one may be supported by that of the other. This perhaps would double the number of necessary inspectors, making the expense of the service something over $9,000. It is reasonably safe to state, however, that with such an expense for competent service, or perhaps with a slightly added expense, the typhoid fly could be largely eliminated in the District of Columbia as an element in the transfer of disease; and the difficulty which the authorities have had in locating the cause of a very considerable proportion of the cases of typhoid in the past two or three years indicates plainly to the mind of the writer that the typhoid fly is a much more important element than has been supposed. It is a comforting, although comparatively insignificant, fact that as a matter of common observation in certain sections of the city the typhoid fly has been much less numerous during the past summer than in previous years. The writer is inclined to attribute this to the gradual disappearance of horse stables in such sections, brought about by the rapidly increasing use of motor vehicles.

A significant paragraph in Mr. Newstead's Liverpool report, referred to above, contains the following words:

> The most strenuous efforts should be made to prevent children defecating in the courts and passages; or that the parents should be compelled to remove such matter immediately; and that defecation in stable middens should be strictly forbidden. The danger lies in the overwhelming attraction which such fecal matter has for house flies, which later may afterwards come into direct contact with man or his foodstuffs. They may, as Veeder puts it, "In a very few minutes * * * load themselves with dejections from a typhoid or dysenteric patient, not as yet sick enough to be in hospital or under observation, and carry the poison so taken up into the very midst of the food and water ready for use at the next meal. There is no long, roundabout process involved."

The writer has already referred to this general subject in his remarks on the depositing of excrement in the open within town or city limits, but Newstead's specific reference to children reminds one that in the tenement districts of the older great cities of England and other parts of Europe there occur opportunities for transfer of disease which, while probably less numerous in the newer cities of the United States, nevertheless must still exist and be a constant danger.

We have thus shown that the typhoid or house fly is a general and common carrier of pathogenic bacteria. It may carry typhoid fever, Asiatic cholera, dysentery, cholera morbus, and other intestinal diseases; it may carry the bacilli of tuberculosis and certain eye diseases. It is everywhere present, and may be disposed of with comparative ease. It is the duty of every individual to guard so far as possible against the occurrence of flies upon his premises. It is the duty of every community, through its board of health, to spend money in warfare against this enemy of mankind. This duty is as pronounced as though the community were attacked by bands of ravenous wolves.

As a matter of fact, large sums of money are spent annually in the protection of property in the United States and on matters pertaining to health. But the expenditure for fly protection is very small and misdirected. There is much justification for the criticism published editorally in the Journal of the American Medical Association for August 22, 1908, under the caption "National farm commission and rural sanitation:"

> The President calls attention to the fact that all efforts to aid the farmers have hitherto been directed to improving their material welfare, while the man himself and his family have been neglected. Nowhere is this more marked than in the attitude of the General Government in matters relating to sanitation. It is a trite saying that whereas the Government, through the Department of Agriculture, aids the farmer generously in caring for the health of his hogs, sheep, etc., it does nothing for his own health. The Government issues notices to the farmer of the injury done to his crops by the cotton-boll weevil and the potato bugs and how to combat it, but the injury the mosquito does in spreading malaria to the people who pick the cotton and hoe the potatoes is not impressed on him. The fact that horseflies may carry anthrax to his cattle is dealt with at considerable length, but the diseases which the house fly spreads to the milk and to the farmer's family attract practically no attention. How to build a hog pen or a sanitary barn is the subject of a number of government publications, but how to build a sanitary privy, which will prevent the spread of typhoid, hook-worm, and many other diseases, is regarded as of strictly local interest.

But this criticism is not entirely justified, since there was published by the Bureau of Entomology of the United States Department of

Agriculture in 1900 a Farmers' Bulletin entitled "How Insects Affect Health in Rural Districts," in which all of the points mentioned by the editor of the Journal of the American Medical Association have been touched upon, and at the date of present writing 192,000 copies of this bulletin have been distributed among the people. Moreover, a number of years ago a circular was published on the subject of the house fly, calling attention to its dangers and giving instructions such as are covered in a general way in this article, and some 18,000 copies of this circular have also been distributed. This is an indication that the General Government is by no means blind to the people's needs in such matters as we have under consideration, but further work should be done. That the English Government is awaking to the same need is shown by the fact that in the parliamentary vote of the present year, in aid of scientific investigations concerning disease, one of the projects supported by the General Government was the investigation of Doctors Copeman and Nuttall on flies as carriers of disease.

A leading editorial in the Washington Evening Star of October 20, 1908, bears the heading "Typhoid a national scourge," arguing that it is to-day as great a scourge as tuberculosis. The editorial writer might equally well have used the heading "Typhoid a national reproach," or perhaps even "Typhoid a national crime," since it is an absolutely preventable disease. And as for the typhoid fly, that a creature born in indescribable filth and absolutely swarming with disease germs should practically be invited to multiply unchecked, even in great centers of population, is surely nothing less than criminal.

ENDEMIC DISEASE AS AFFECTING THE PROGRESS OF NATIONS.

In referring to the spread of malaria in Greece, the influence of this disease on the rise and fall of national power has been touched upon in an earlier paragraph of this report. The subject is one of the widest importance and deserves a more extended consideration.

The following paragraphs are quoted from Ronald Ross's address on "Malaria in Greece," delivered before the Oxford Medical Society November 29, 1906:

> Now, what must be the effect of this ubiquitous and everlasting incubus of disease on the people of modern Greece? Remember that the malady is essentially one of infancy among the native population. Infecting the child one or two years after birth, it persecutes him until puberty with a long succession of febrile attacks, accompanied by much splenomegaly and anæmia. Imagine the effect it would produce upon our own children here in Britain. It is true that our children suffer from many complaints—scarlatina, measles, whooping cough—but these are of brief duration and transient. But now add to these, in imagination, a malady which lasts for years, and may sometimes attack every child in a village. What would be the effect upon our population, especially our rural population—upon their numbers and upon the health and vigor of the survivors? It must be enormous in Greece. People often seem to think that such a plague strengthens a race by killing off the weaker individuals; but this view rests upon the unproven assumption that it is really the weaker children which can not survive. On the contrary, experience seems to show that it is the stronger blood which suffers most—the fair, northern blood which nature attempts constantly to pour into the southern lands. If this be true, the effect of malaria will be constantly to resist the invigorating influx which nature has provided; and there are many facts in the history of India, Italy, and Africa which could be brought forward in support of this hypothesis.

> We now come face to face with that profoundly interesting subject, the political, economical, and historical significance of this great disease. We know that malaria must have existed in Greece ever since the time of Hippocrates, about 400 B. C. What effect has it had on the life of the country? In prehistoric times Greece was certainly peopled by successive waves of Aryan invaders from the North, probably a fair-haired people, who made it what it became, who conquered Persia and Egypt, and who created the sciences, arts, and philosophies which we are only developing further to-day. That race reached its climax of development at the time of Pericles. Those great and beautiful valleys were thickly peopled by a civilization which in some ways has not since been excelled. Everywhere there were cities, temples, oracles, arts, philosophies, and a population vigorous and well trained in arms. Lake Kopais, now almost deserted, was surrounded by towns whose massive works remain to this day. Suddenly, however, a blight fell over all. Was it due to internecine conflict or to foreign conquest? Scarcely; for history shows that war burns and ravages, but does not annihilate. Thebes was thrice destroyed, but thrice rebuilt. Or was it due to some cause, entering furtively and gradually, sapping away the energies of the race by attacking the rural population, by slaying the new-born infant, by seizing the rising generation, and especially by killing out the fair-haired descendant of the original settlers, leaving behind chiefly the more immunized and darker children of their captives, won by the sword from Asia and Africa? * * *
>
> I can not imagine Lake Kopais, in its present highly malarious condition, to have been thickly peopled by a vigorous race; nor, on looking at those wonderful figured tombstones at Athens, can I imagine that the healthy and powerful people represented upon them could have ever passed through the anæmic and splenomegalous infancy (to coin a word) caused by widespread malaria. Well, I venture only to suggest the hypothesis, and must leave it to scholars for confirmation or rejection. Of one thing I am confident, that causes such as malaria, dysentery, and intestinal entozoa must have modified history to a much greater extent than we conceive. Our historians and economists do not seem even to have considered the matter. It is true that they speak of epidemic diseases, but the endemic diseases are really those of the greatest importance. * * *
>
> The whole life of Greece must suffer from this weight, which crushes its rural energies. Where the children suffer so much, how can the country create that fresh blood which keeps a nation young? But for a hamlet here and there, those famous valleys are deserted. I saw from a spur of Helicon the sun setting upon Parnassus, Apollo sinking, as he was wont to do, toward his own fane at Delphi, and pouring a flood of light over the great Kopaik plain. But it seemed that he was the only inhabitant of it. There was nothing there. "Who," said a rich Greek to me, "would think of going to live in such a place as that?" I doubt much whether it is the Turk who has done all this. I think it is very largely the malaria.

In considering carefully this suggestive argument of Major Ross, does it not appear to indicate the tremendous influence that the prevalence of endemic disease must exert upon the progress of modern nations, and does it not bring the thought that those nations that are most advanced in sanitary science and preventive medicine will, other things being equal, assume the lead in the world's work? Who can estimate the influence of the sanitary laws of the Hebrew scriptures upon the extraordinary persistence of that race through centuries of European oppression, centuries full of plague years and of terrible mortality from preventable disease? And what more striking example can be advanced of the effect of an enlightened and scientifically careful attention to the most recent advances of preventive medicine upon the progress of nations than the mortality statistics of the Japanese armies in the recent Russian-Japanese war as compared with the corresponding statistics for the British army during the Boer war immediately preceding, or the American army during the Spanish war at a somewhat earlier date?

The consideration of these elements of national progress has been neglected by historians, but they are nevertheless of deep-reaching importance and must attract the immediate attention in this age of advanced civilization. The world has entered the historical age when national greatness and national decay will be based on physical rather than moral conditions, and it is vitally incumbent upon nations to use every possible effort and every possible means to check physical deterioration.

SUMMARY OF LOSSES FROM INJURIOUS INSECTS.

This report on the economic loss to the people of the United States through insects that carry disease is one of a series of reports made to the Commission on the Conservation of Natural Resources on the losses due to injurious insects. The insect losses in the United States are undoubtedly heavier than in any other country in the world. There are many insect pests for every plant grown on the farm and for every kind of tree represented in our natural forests. All domestic animals suffer seriously from parasitic and other insects, and above the reduction in the annual increase of products is the heavy loss occasioned by insects to the accumulated stores of previous years of such staples as grains, tobacco, manufactured woods, hides and furs, and certain animal food products. There is in addition, also, the serious check on production caused by the prevalence of insect-borne diseases.

Estimating all of these losses at the lowest reasonable percentage, a total so enormous is reached that it staggers the belief of anyone who has not given the subject careful study or considered the enormous annual output of products involved.

To meet the requirements of the schedule of inquiries submitted, the losses which are chargeable to insect pests fall under four heads, namely, (1) relating directly to plant products other than natural forests; (2) relating to natural forests and forest products; (3) due to insect enemies of live stock; and (4) due to the relation of insects to disease. To get a comprehensive view, the amount of loss estimated as falling under each of these four heads is here indicated.

Subject.	Percentage of loss on annual output or value.	Amount of loss.
Plant products of the farm	10-30	$652,500,000
Natural forest products	10	130,000,000
Animal products	10	267,000,000
Insects versus disease		200,000,000
Total		1,249,500,000

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